THE TAXONOMY AND DISTRIBUTION OF *PETAURUS GRACILIS* (MARSUPIALIA: PETAURIDAE), WITH NOTES ON ITS ECOLOGY AND CONSERVATION STATUS

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Petaurus gracilis is morphologically and biochemically distinct from *P. norfolcensis* from which it is geographically isolated. Since its description in 1883, *P. gracilis* has been recorded from 22 localities between Ingham and Tully (80km) in coastal lowland woodland below the 90m contour. Its restricted distribution is determined by very high seasonal rainfall, a mean dry quarter precipitation usually greater than 100mm and a woodland blend of vegetation that is shaped and maintained by fire. The presence of one of the northern bloodwoods (*Eucalyptus intermedia*, *E. clarksoniana* or *E. dolichocarpa*) and an accompanying species of 'bird-syndrome' arillate *Acacia* are suggested as a minimal basis for suitable habitat. Among exudivores, *Petaurus gracilis* appears to be more a dietary opportunist, feeding on nectar, pollen, arthropods, *Acacia* exudates, lerp, and honeydew when these items become seasonally available. More notable dietary items include *Acacia* arils, *Xanthorrhoea* scape exudates and sap (or kino) of *E. intermedia*. Interpretation of its socioecology was impeded by small sample size but home range size for an adult female was determined at 23ha and a quasi-polygynous mating system was suggested. *Petaurus gracilis* is endangered throughout its range by habitat destruction, fragmentation and changes in local fire regimes that together have resulted in an 80% loss of its preferred habitat. □ *Petaurus gracilis, Petaurus norfolcensis, Petauridae, taxonomy, distribution, conservation, Queensland, Australia, Mahogany Glider, habitat, ecology, tropical woodland, diet, behaviour.*

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Since its description in 1883 by Charles de Vis, the taxonomic status and distribution of *Petaurus gracilis* has been a matter for conjecture. De Vis failed to designate a holotype and no specimens are referred to in the literature or known from collections outside the Queensland Museum. Five years after its description, Thomas (1888) synonymized *P. gracilis* with *P. norfolcensis* (then *Petaurus sciureus*) and Mackay (1988) dealt with it similarly. Other references to the name *P. gracilis* deal with it as a northern subspecies of *P. norfolcensis* (Iredale & Troughton, 1934; Troughton, 1941; Tate, 1945; Fleay, 1947; 1954; Marlow, 1962; Suckling, 1983; Alexander, 1981; Colgan & Flannery, 1992). Given the lack of *P. gracilis* specimens in collections, and the subsequent anonymity of the species, it is probable that its synonymy has resulted from a broad interpretation of de Vis's brief description rather than from a physical examination of the few *P. gracilis* specimens. Also, the assigning of *P. norfolcensis gracilis* to a wide range of Queensland examples of *P. norfolcensis* has resulted from too broad an interpretation of de Vis's loose reference

to its collection locality, 'North of Cardwell' (de Vis, 1883: 620).

In 1990 I reported three previously unregistered museum specimens, whose large size, long, thin, short-haired tails, pattern of fur colouration and measurements agreed closely with de Vis's description of *P. gracilis* (Van Dyck, 1990). These skins had been collected by Kendall Broadbent in 1886, from somewhere on, or near Mt Echo, 18km SW Cardwell. At the time of that report, given the faded, deteriorated quality of the skins, the fragmentary nature of cranial and dental material extracted from them, and inexplicable inconsistencies between the de Vis description and data associated with old identification tags attached to the skins, it was concluded that until additional material came to hand, *P. gracilis* should remain a junior synonym of *P. norfolcensis*. However, I also concluded that it was inappropriate to continue the use of *P. norfolcensis gracilis* in respect of all northeastern and mideastern Queensland examples of *P. norfolcensis* as they were indistinguishable from their more southern conspecifics.

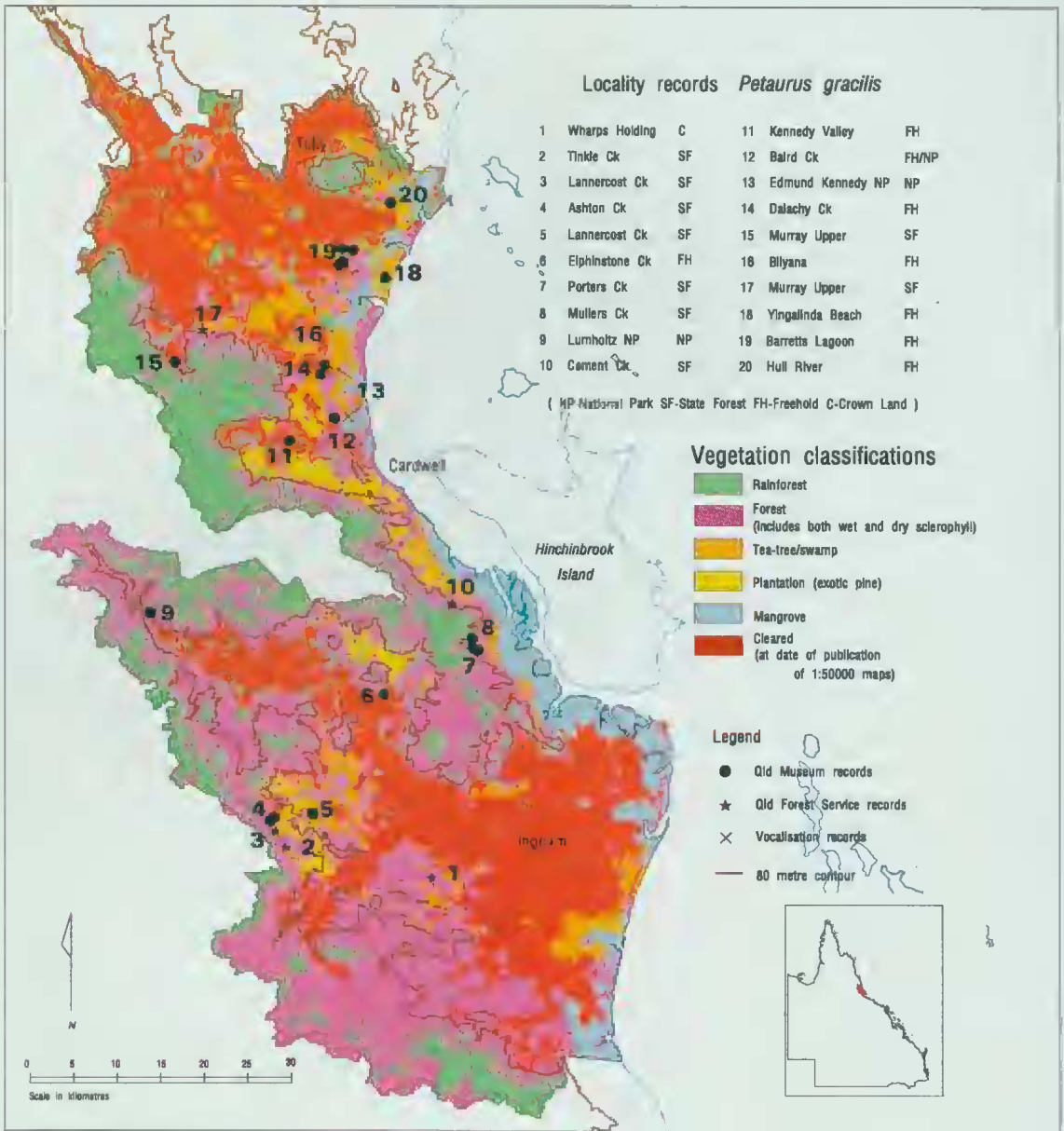In December 1989, living representatives of *P.*

Locality records *Petaurus gracilis*

1	Wharps Holding	C	11	Kennedy Valley	FH
2	Tinkle Ck	SF	12	Baird Ck	FH/NP
3	Lannercost Ck	SF	13	Edmund Kennedy NP	NP
4	Ashton Ck	SF	14	Dalachy Ck	FH
5	Lannercost Ck	SF	15	Murray Upper	SF
6	Elphinstone Ck	FH	16	Bilyana	FH
7	Porters Ck	SF	17	Murray Upper	SF
8	Mullers Ck	SF	18	Yingalinda Beach	FH
9	Lumholtz NP	NP	19	Barretts Lagoon	FH
10	Cement Ck	SF	20	Hull River	FH

(NP-National Park SF-State Forest FH-Freehold C-Crown Land)

Vegetation classifications

- Rainforest
- Forest (includes both wet and dry sclerophyll)
- Tea-tree/swamp
- Plantation (exotic pine)
- Mangrove
- Cleared (at date of publication of 1:50000 maps)

Legend

- ● Qld Museum records
- ★ Qld Forest Service records
- × Vocalisation records
- — 80 metre contour

FIG. 1. Locality records for *Petaurus gracilis* (see Table 1 for details).

gracilis were located on freehold land at Barretts Lagoon (18°02'S, 145° 58'E), 14km SE of Tully. At that time, one specimen (JM7605) was collected for museum accession. In January 1990 the collection site was cleared for cultivation of bananas and pineapples. In February 1991 an adult female was captured nearby, photographed (Fig. 2) and subsequently (May) released at the site of capture (Van Dyck, 1992a). Further surveys conducted during 1991-2 extended and refined the range of the species and provided data suggesting that the long-term conservation of the species could be a matter of grave concern.

The aim of the present study was to: 1, clarify the taxonomic status of *P. gracilis* with respect to *P. norfolcensis* (in particular) and other members

of the genus; 2, provide preliminary data on the distribution, habitat requirements, diet and socioecology of *P. gracilis*; and 3, assess the conservation status of the species.

METHODS

SYSTEMATICS

Nomenclature for molar tooth structure follows Woodburn et al. (1987), and cheek tooth number follows Archer (1978) (see explanation in Marshall, 1987). Dental and cranial measurements were made after the method shown in Fig. 3. Specimens were measured to the nearest 0.01mm using NSK electronic digital calipers. Specimens compared in diagnoses were adults with fully erupted fifth molars. T-tests were used to test for statistical significance.

Specimens from the following institutions were examined: Queensland Museum (specimens refered to in text prefixed by J or JM); Australian Museum, Sydney (specimens prefixed by M); Australian National Wildlife Collection, Division of Wildlife Research, Canberra; Bishop Museum, Honolulu; British Museum (Natural History),

London; American Museum of Natural History, New York; Museum of Victoria, Melbourne. Maximum numbers of individuals included in statistical analyses were: *P. norfolcensis* 70, *P. breviceps* 21, *P. australis* 11, *P. abidi* 5 and *P. gracilis* 11. Old skins (JM5521, JM5522, JM5523) were omitted from statistical analyses.

FIELD SURVEYS

Field observations and surveys were made during the following periods: 1-13 Dec 1989, 9-24 Feb 1991, 9-24 May 1991, 2-16 Aug 1991, 23-29 Nov 1991, 29 Feb-13 Mar 1992, 13-14 May 1992, 24 May-6 June 1992, 26 Sept-11 Oct 1992, 24-26 Nov 1992. Fieldwork during 1989 and 1991 concentrated on capture and radiotelemetry of individuals at Barretts Lagoon, while 1992 fieldwork was concerned with an assessment of distribution outside the immediate area of the lagoon.

CAPTURE TECHNIQUES

Wire cage and aluminium live traps were set 2-7m above the ground. Traps included Elliott aluminium ($460 \times 160 \times 150$mm and $330 \times 95 \times 100$mm) Mascot wire ($560 \times 205 \times 215$mm),

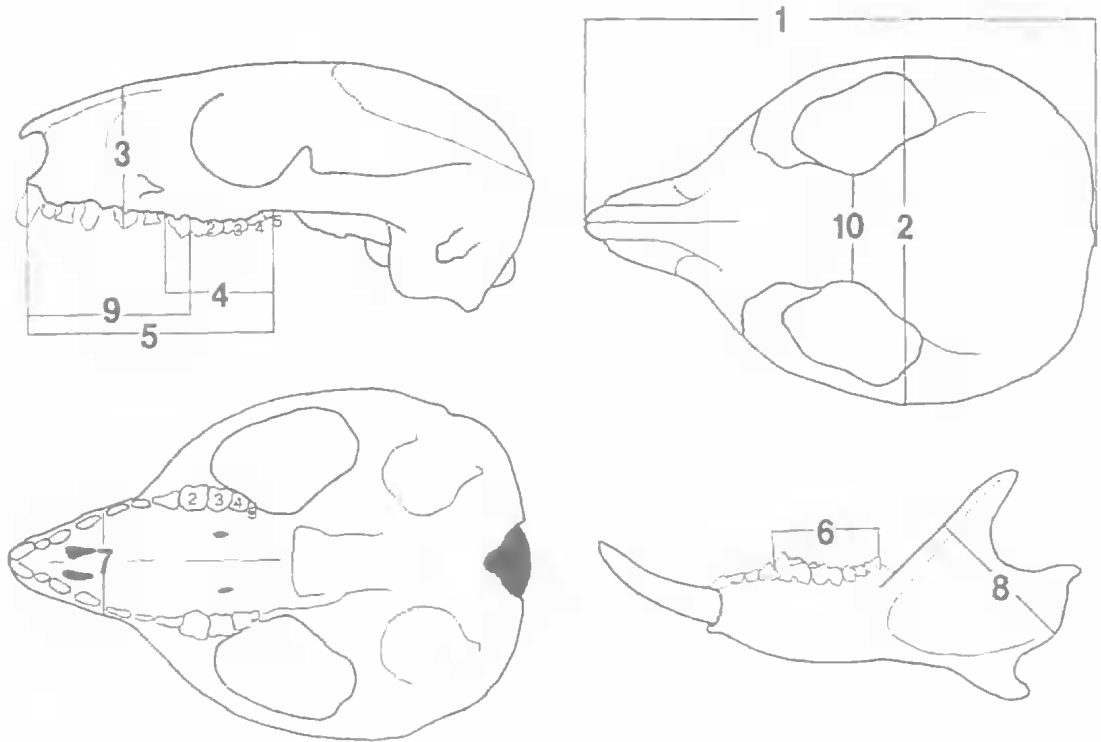FIG. 2. Adult female *Petaurus gracilis* T4026, caught Barretts Lagoon 22 Feb 1991, released 11 May 1991.

FIG. 3. Method used in skull and tooth measurement: 1, maximum skull length; 2, zygomatic width; 3, rostrum height; 4, upper molar row length; 5, upper tooth row length; 6, lower molar row length; 7, rostral width between upper canines; 8, width of ascending ramus; 9, upper incisor-premolar row; 10, interorbital width.

Tamohawk wire (400×140×140mm) and Acme wire (440×200×180mm). Traps were protected by plastic bag weather shields and supported on horizontal ply baseboards screwed to right-angle iron brackets which were nailed to tree trunks. Baits consisted of a sugar/honey toffee or a mixture of honey and sweetened condensed milk. Additional attractants of diluted honey, sugar water or raspberry cordial were sprayed on tree trunks near trap entrances to lure gliders into the traps. Traps were laid along transects on trunks of living and dead trees, or arranged in groups of up to 12 among flowering *Xanthorrhoea johnsonii* chosen for signs of *P. gracilis* visitation by way of footprinted flower stalks. Trapping was carried out during the following periods: 1-13 Dec 1989 (205 trap nights); 9-24 Feb 1991 (230 trap nights); 9-24 May 1991 (110 trap nights); 29 Feb-13 Mar 1992 (176 trap nights). Trap-nights totalled 721 and covered 10 sites at Barretts Lagoon and one at Edmund Kennedy National Park, Cardwell.

At the beginning of the survey (Feb and May 1991), 48 artificial nesting hollows were installed and left for between 16-19 months at 2 sites at Barretts Lagoon to act as a back-up should the trapping program fail. Of these, 34 were attached to tree trunks (Feb 21) at the Barretts Lagoon 'Rice Fields' (18°01'S, 145°58'E) where an adult female had been caught (19 Feb). This 200-400m wide strip of woodland was bordered to the west by Barretts Lagoon Road and to the east by natural treeless swales (Fig. 19). Given the irregular shape of the site, the 34 hollows were arranged in a grid of six rows (1 row of 7 hollows, 2 of 6, 3 of 5) with minimum spacings of approximately 50m. On 17 May 1991, 14 additional artificial nests were installed further east (18°01'S, 145°59'E) and set along 700m of north-south track and spaced at 50m. The choice of 'nest' design was based roughly on the trap of Mawbey, (1989) which was shown to be highly effective for catching sugar gliders *P. breviceps* in the field. The artificial nesting hollows used in my study were of 160mm (diameter) PVC sewer pipe cut to 500mm lengths, capped at either end and

FIG. 4. One of 48 PVC artificial nest hollows used in the survey. Each was strapped onto a trunk with fencing wire.

drilled with a 65mm (diameter) entrance hole 120mm from the top of the tube (tube vertical) These hollows were furnished internally with a 280mm 'ladder' of roughened timber screwed directly below the entrance hole while the floor was perforated for drainage. All tubes were painted a dull brown-green, numbered and strapped vertically to trunks at heights of 3-7m using fencing wire (Fig. 4). All tubes were inspected at least once per survey period and all but one (occupied by a family of *P. breviceps*) were removed from the two sites by 8 Sept 1992.

One *P. gracilis* (Fig.2) was captured in a mist-net enclosure constructed around the outside of its den in a hollow Swamp Mahogany trunk (see Van Dyck, 1992a). Two were captured by 'port-holing' hollow trunks of known nest trees. This practice involved cutting a rectangular hole (approx 120mm × 180mm) into the den and extracting the glider(s) by hand. The 'port-hole' was then plugged with a hardwood block which was

wired for later access. One individual was caught by shaking it from a small tree (see Van Dyck, 1992b).

HANDLING AND RADIO-TRACKING PROCEDURES

Captured individuals were weighed, measured, sexed, assigned to an age category from the condition of wear of the first upper incisors (Suckling, 1980; Alexander, 1981), tagged on one ear with a numbered (T40_ _) fingerling ear-tag ('FF', Salt Lake Stamp Co., Utah) and (where possible) released back into the den from which they were taken. Gliders used in radio tracking were fitted with a Titley (Ballina, NSW) 'Microlite', two-stage transmitter either attached to a soft leather collar with a protruding 15cm whip antenna or epoxy-potted into a small disc (diameter 26mm × 10mm high) with a protruding 28cm antenna. The ventral surface of the epoxy disc transmitter was glued to the animals mid-back (Selleys Supa Glue) after a circle of fur approximating the diameter of the disc had been cropped close to the glider's skin. The short hair stubble that remained, provided a rough bonding surface for the glue on the transmitter and at the same time protected the animal's skin from contact with the adhesive. Long hair surrounding the positioned disc was then glued over the dorsal surface of the transmitter, in effect hiding it and leaving only the whip antenna exposed. The total weight of the transmitter package was approximately 11g. A 2000 channel 'Regal 2000' (Titley) portable receiver operating on the 150.000-151.999mHz band, and a 2 element hand-held H-frame antenna were used to locate animals.

HOME RANGE DETERMINATION

Preliminary home range estimates were determined for one adult female (T4026) and two sub-adult female gliders (T4027 and T4028, presumed to be the offspring of T4026). During the course of the study only one male (T4030) was captured and radio-tagged. This male dislodged its transmitter on the third day and only den site data was recorded. Although gliders were strictly nocturnal, a morning (0600hrs) and afternoon (1600hrs) den fix was usually taken for each tagged animal. Because animals proved difficult to catch and visits to the area were irregular (and often 3-4 months apart), animals were radio-tracked both continuously and randomly during each visit. Direct observation was used to maximise return of information other than that associated solely with home range. Trees visited on a

Site	Locality	Lat.	Long.	Alt.m asl.	Nature of record (No. recorded)	Dates	Collector/ Observor	Tenure
i	"North of Cardwell"	—	—	—	species description de Vis (1883)	1883	K. Broadbent	—
ii	"Mt Echo"	—	—	—	JM5521 (AM) JM5522 (AF) JM5523 (AF)	1886	K. Broadbent	—
1	*Wharps Holding	18°41'18"S	146° 04'25"E	20-40	sighting (2)	13.10.92	L. Logan T. Eyre	Crown
2	*Tinkle Creek	18°39'20"S	145°54'55"E	40	sighting (1)	15.10.92	T. Eyre	S.F.
3	*Lannercost Creek	18°38'20"S	145°54'15"E	90	sighting (1)	15.10.92	T. Eyre	S.F.
4	Ashton Creek	18°37'41"S	145°53'57"E	70	sighting (1)	01.06.92	S. Van Dyck S. Burnett	S.F.
		18°37'26"S	145°54'12"E	60-70	sighting (2)	01.06.92	"	S.F.
5	Lannercost Creek	18°37'13"S	145°56'44"E	30-40	sighting (1)	01.06.92	"	S.F.
6	Elphinstone Creek	18°29'42"S	146°01'26"E	20-40	sighting (1)	11.03.92	"	Freehold
7	Porters Creek	18°26'57"S	146°07'35"E	35	JM9015 (AF)	10.03.92	"	S.F.
		18°26'47"S	146°07'17"E	35	sighting (1)	13.05.92	S. Van Dyck J. Kehl I. Rob	S.F.
8	Mullers Creek	18°26'13"S	146°07'15"E	20-40	sighting (2)	13.05.92	"	S.F.
9	Lumholtz N.P	18°24'30"S	145°46'10"E	40-60	sighting (1)	11.03.92	S. Van Dyck S. Burnett	N.P.
10	*Cement Creek	18°23'55"S	146°05'57"E	20-40	sighting (1)	12.10.92	C. Corben	S. F.
11	Kennedy Valley	18°13'31"S	145°55'23"E	0-20	JM8549 (AF)	-.10.90	E. Gallipo	Freehold
				0-20	JM8550 (joey F)	-.10.90	"	Freehold
12	Baird Creek	18°12'11"S	145°58'17"E	0-10	sighting (1)	05.03.92	S.Van Dyck S. Burnett	Freehold/ N.P.border
13	Edmund Kennedy N.P.	18°12'04"S	145°59'14"E	0-20	call (1)	05.03.92	"	N.P.
		⁺18°08'43"S	145°57'50"E	0-20	call (1)	04.03.92	"	N.P.
14	Dalachy Creek	18°09'26"S	145°57'26"E	0-10	JM9014 (AM)	08.03.92	"	Freehold
		18°08'51"S	145°57'40"E	0-10	sighting (2)	03.03.92	"	Freehold
15	Murray Upper	18°08'38"S	145°47'54"E	40-60	JM9016 (AF)	10.03.92	"	S.F.
16	Bilyana	18°07'S	145°56'E	0-20	private mount	- .- .74	T. Marsilio	Freehold
17	*Murray Upper	18°06'30"S	145°49'40"E	20-40	sighting (1)	16.10.92	C. Corben	S.F.
18	Yingalinda Beach	18°03'18"S	146°01'37"E	0-10	sighting (1)	18.08.91	S. Van Dyck P. Stumkat	Freehold
19	Barretts Lagoon i. South-west bank	18°02'31"S	145°58'36"E	0-10	JM7400 (AM)	09.12.89	"	Freehold
				0-10	sighting (8)	06.12.89- 08.12.89	"	Freehold
	Barretts Lagoon ii. North-east bank	18°02'23"S	145°58'46"E	0-10	sight(1) & call (1)	09.08.91	P. Stumkat	Freehold
		18°02'22"S	148°58'52"E	0-10	JM7290 (AF with joeys JM9729 & JM9730)	14.02.73	G. Gordon R.J. Grimes	Freehold
	Barretts Lagoon iii. " Rice Fields	18°01'26"S	148°58'46"E	0-10	sighting (10)	15.02.91- .02.03.92	S. Van Dyck P. Stumkat S. Burnett B.&C. Cowell	Freehold
	Barretts Lagoon iv East	18°01'33"S	145°59'34"E	0-10	sight (9) & call (2)	17.05.91- 29.11.91	"	Freehold
20	Hull River	17° 58'29"S	146°02'02"E	0-20	sighting (1)	2.10.92	S. Van Dyck S. Burnett	Freehold

glider's traversed route were marked with flagging tape and surveyed during the day.

It is acknowledged that direct observation through continuous tracking may have led to an underestimation of home range size through loss of independence of fixes (Swihart & Slade, 1985). To overcome this problem, where continuous tracking was employed, 30 minute fixes were extracted from examination of each route plotted through time. Quin et al. (1992) considered that 30min radio fixes for fast moving mammals such as species of *Petaurus* were adequate to assume independence of data points. Fixes were taken from adult female T4026 over a period of 4 full nights and 13 partial nights (including den fixes) during May, August and November 1991 (110 fixes), while those from sub-adult female T4028 were taken over a period of 1 full night and 9 partial nights (including den fixes) during May 1991 (36). Fixes from sub-adult female T4027 were taken over a period of 1 full night and 6 partial nights (including den fixes) during May 1991 (36 fixes). Estimates of home range area were generated using the harmonic mean distance minimum (HM) using 95% isopleths (see Dixon & Chapman, 1980) and the minimum convex polygon (MCP: Mohr 1974). The utility and appropriateness of the HM for describing home ranges of animals such as sugar gliders was demonstrated by Quin et al. (1992). Estimates were generated with the RANGES IVm software package (R. E. Kenward; Institute of Terrestrial Ecology, Furzebrook Research Station, Wareham, United Kingdom).

SPOTLIGHTING

12 volt, 150mm and 230mm 'Powa Beam Spotlights' (Byron Bay, NSW) were used from a vehicle, the 230mm (9") 'Powa-lite' (1 million CP, quartz halogen) being particularly efficient. 150mm, 12V spotlights powered by wet cell motorbike batteries were used for on-foot surveys. 3 and 4 'D'cell 'Mag-Lite' torches (Mag Instruments - Ontario, Calif) were used to observe radio-tagged animals. The expanding beam of these torches greatly facilitated detection of gliders leaping from treetops. A total of 1334 manhours were spent spotlighting for *P. gracilis* (Table 3). *Petaurus gracilis* was consistently difficult to locate (see Davey, 1984; Menkhorst et al., 1988 for similar problems with *P. norfolcensis*). It was practically silent, evasive in spotlights

and its eyes reflected poorly (dull red). Animals attracted by playback recordings of *P. norfolcensis* or *P. gracilis* vocalisations (see Kavanagh & Rohan-Jones, 1982) or by imitated calls aborted their approach if a light was turned on. In approximately 877 manhours of non-telemetry spotlighting (547 hours from a vehicle, 330 on foot), 22 of the 28 animals located by this method were first observed from a vehicle.

PALYNOLOGICAL ANALYSIS

Pollen analysis was undertaken by M. Dettmann (University of Qld) on five faecal samples collected between Feb and Nov 1991 from Barretts Lagoon. Two strew slides were prepared from each sample. One, contained crushed but otherwise untreated faecal material mounted in glycerine jelly under a glass coverslip. The second slide contained faecal material treated with warm 5% KOH for 5min, then washed thoroughly under distilled water and sieved through a 240μ mesh screen prior to mounting in glycerine jelly. The untreated slides were examined to estimate relative proportions of pollen, other plant tissue and insect fragments in each sample, and to estimate the proportion of pollen with their contents (intine) in place. Qualitative and quantitative analyses of the pollen assemblages represented in each sample were determined from the treated slide.

VEGETATION ANALYSES

At each site where a glider had been observed (Table 1) the vegetation was assessed visually and classified into one of the vegetation types of Tracey (1982). A vegetation proforma was prepared by W. Lavarack and R. Cummings (Queensland Department of Environment and Heritage) for each site. Trees, shrubs and grasses were recorded in terms of their relative abundance (A-abundant, C-common, O-occasional, U-uncommon). An estimate was made of projective foliage cover (% of the sample site occupied by the vertical projection of foliage only, see McDonald et al., 1984) and the soil type noted. Nest sites of four individuals were described in more detail by P. Stumkat and I after the manner of Menkhorst et al. (1988). A square quadrat, centered on a frequently used denning tree, was defined with its apices 30m to the N, S, E, and W (total area $1800m^2$). Densities of trees were then presented as mean number of trees per $1000m^2$. Within each quadrat all trees and shrubs

TABLE 1. Site and record details for *P. gracilis* sorted from the south by latitude. Age as adult (A) or juvenile (J). Sex as male (M) or female (F). Tenure includes National Park (N.P.)3 and State Forest (S.F.) *Site inside (east of) NP fence, but fence west of gazetted park boundary. * Record courtesy of J. Kehl, QFS.

FIG. 5. Comparison of size in four species of *Petaurus*. L to R. *P. gracilis* (adult male JM9014, Dalachy Creek), *P. abidi* (adult female M21664, Wilbeite, Papua New Guinea), *P. norfolcensis* (adult female J11514 Warwick), *P. breviceps* (adult female JM7396, Barretts Lagoon). Scale divisions in cm.

taller than 3m were identified, counted and their height and circumference-at-breast-height measured (Table 4).

BIOCHEMICAL ANALYSIS

Frozen tissues of adult female JM8459 (Kennedy Valley) were the subject of electrophoretic allozymic analysis as described by Colgan & Flannery (1992).

SYSTEMATICS

Petaurus gracilis (de Vis, 1883)

DIAGNOSIS

Petaurus gracilis is distinguished from *P. norfolcensis* by its larger size, reflected in the following measurements (in mm) for which respective values show no overlap:

Maximum skull length: mean 51.14, R= 49.80-52.60, N= 7, SD= 0.95 vs 45.33, R= 40.96-49.05, N= 68, SD= 1.80.

Zygomatic width: mean 34.14, R= 32.90-35.08, N= 7, SD= 0.71 vs 30.15, R= 27.81-32.59, SD= 1.19.

Rostrum height: mean 14.02, R= 13.00-15.93, N= 9, SD= 0.84 vs 11.54, R= 9.89-12.68, SD= 0.62.

Tail-vent length: mean 353.50, R= 300-390, N= 10, SD= 25.76 vs 239.43, R= 195-290, N= 30, SD= 22.06.

P. gracilis has a significantly (P<0.001) narrower interorbital width than *P. norfolcensis*: mean 8.59, R= 7.30-9.82, N= 9, SD= 0.95 vs 9.60, R= 7.97-11.73, N= 69, SD= 0.70.

P. gracilis is significantly (P<0.001) larger than *P. norfolcensis* in the following measures (Fig. 5):

Head-body length: mean 247.45, R= 215-265, N= 11, SD= 15.86 vs 200.72, R= 165-232, N= 29, SD= 17.17.

Hind foot length: mean 39.61, R= 37-43, N= 11, SD= 2.00 vs 32.03, R= 24-38, N= 29, SD= 3.01.

Weight: mean 349.45, R= 255-410, N= 11, SD= 39.69 vs 170.47, R= 110-301, N= 30, SD= 43.57.

Upper molar row length: mean 8.68, R= 8.30-9.00, N= 9, SD= 0.21 vs 8.06, R= 7.37-8.90, N= 70, SD= 0.34.

Upper tooth row length: mean 23.90 R= 23.00-24.80, N= 9, SD= 0.51 vs 21.78, R= 19.76-23.51, N= 69, SD= 0.84.

Lower molar row length: mean 9.43, R= 9.00-9.91 N= 9, SD= 0.28 vs 8.73, R= 7.73-9.50, N= 69, SD= 0.34.

Upper incisor-premolar row length: mean 16.03, R= 15.47-16.59, N= 9, SD= 0.34 vs 14.46, R= 12.95-15.99, N= 69, SD= 0.69.

Rostral width between upper canines: mean 9.69, R= 9.10-10.30, N= 9, SD= 0.29 vs 8.67, R= 7.60-10.00, N= 69, SD= 0.46.

Width of ascending ramus: mean 13.13, R= 12.09-13.70, N= 9, SD= 0.32 vs 11.15, R= 9.93-12.50, N= 69, SD= 0.59.

Figs 6, 7 and 8 demonstrate the relationship between *P. gracilis* and *P. norfolcensis* for some of the measures refered to above.

Petaurus gracilis is distinguished from *P. breviceps* by its much larger size, reflected in the following measurements for which respective values show no overlap:

Maximum skull length: mean 51.14 vs 36.07. R= 33.17-37.91, N= 17, SD= 1.23.

Zygomatic width: mean 34.14 vs 24.79, R= 22.53-26.53, N=16, SD= 1.20.

Rostrum height: mean 14.02 vs 8.92, R= 8.29-9.55, N= 19, SD= 0.36.

Width of ascending ramus: mean 13.13 vs 8.18, R= 7.28-9.49, N= 20, SD= 0.56.

Tail-vent length: mean 353.50 vs 192.92, R= 159-235, N= 13, SD= 19.62.

Weight: mean 349.45 vs 93.09, R= 59-118, N= 11, SD= 19.19.

Upper molar row length: mean 8.68 vs 6.37, R= 6.05-7.75, N= 21, SD= 0.20.

TABLE 2. Queensland Museum specimens (prefixed JM) and tagged individuals caught and released (prefixed T). Age as adult (A). sub-adult (SA) or juvenile (J). Sex as male (M) or female (F). Measurements in mm. weight in g. Tail damaged as (d).

Regn #	Locality	Age	Sex	HB	TV	HF	E	Wt	Preservation	Colour phase & comments
JM5521	Mt Echo	A	M	260	365	38	25	—	skin, skull	measurements from old buff skins
JM5522	Mt Echo	A	M	255	340	33	25	—	skin, skull frag	
JM5523	Mt Echo	A	F	252	355	37	25	—	skin, skull frag	
JM7290	Barretts Lagoon	A	F	261	330	42	35	352	skin, skull spirit	buff
JM9729	Barretts Lagoon	J	F	58	60	12	8	—	spirit	hairless young of JM7290
JM9730	Barretts Lagoon	J	F	48	59	11	8	—	spirit	hairless young of JM7290
JM7400	Barretts Lagoon	A	M	265	335	43	36	410	skin, skull, spirit	buff
JM8549	Kennedy Valley	A	F	240	270(d)	38	33	350	spirit	buff
JM8550	Kennedy Valley	J	F	95	121	20	15	43	spirit	buff, pouch young of JM8549
JM9014	Dalachy Ck	A	M	249	354	41	35	350	skin, skull, frozen body	dark
JM9015	Porters Ck	A	F	264	360	40	32	407	skin, skull, frozen body	
JM9016	Murray Upper	A	F	256	346	41	33	370	skin, skull, frozen body	'aberrant' phase
T4026	Barretts Lagoon	A	F	220	300	37	29	345		dark, caught in den 22.02.91
T4027	Barretts Lagoon	SA	F	200	320	32	31	195		dark, caught in nest box #8 10.05.91
T4028	Barretts Lagoon	SA	F	180	330	35		215		dark, caught in nest box #8 10.05.91
T4029	Barretts Lagoon	A	F	250	390	38	27	255		buff, caught while feeding 19.05.91
T4030	Barretts Lagoon	A	M	247	380	38	29	330		buff, caught in den 05.08.91
T4031	Barretts Lagoon	A	F	215	380	37	34	325		buff, caught in den 08.08.91
T4032	Barretts Lagoon	J	M	120	165	26	17	65		buff, nestling of T4026 26.11.91
T4033	Barretts Lagoon	J	F	120	175	24	17	69		buff, nestling of T4026 26.11.91

Upper tooth row length: mean 23.90 vs 16.90, R= 16.04-17.93, N= 20, SD= 0.54.

Lower molar row length: mean 9.43 vs 6.99, R= 6.60-7.91, N= 21, SD= 0.28.

Upper incisor-premolar row length: mean 16.03 vs 11.05, R= 10.24-12.14, N= 20, SD= 0.48.

Rostral width between upper canines: mean 9.69 vs 6.79, R= 6.29-7.30, N= 20, SD= 0.31.

Petaurus gracilis is immediately distinguished from *P. abidi* by the atrophied condition of P^2 in *gracilis*, but which, in *abidi*, is well developed and subequal in crown height to both P^1 and P^3. *P. gracilis* is further distinguished by its reduction in buccal ectoloph enamel on M^2 and M^3 and by the reduction in the paracone relative to the metaconule (the posterolingual cusp previously and commonly termed the hypocone; see Woodburn et al., 1987: 641 for discussion) in M^2. *P. gracilis* is also distinguished from *P. abidi* by its smaller dimensions in the following measurements for which respective values show no overlap:

Interorbital width: mean 8.59 vs 10.42, R= 9.70-11.50, N= 3, SD= 0.78.

Upper molar row length: mean 8.68 vs 9.50, R= 9.30-9.70, N= 2, SD= 0.21.

Petaurus gracilis is distinguished from *P. australis* by its smaller size, reflected in the following measurements (for which respective values show no overlap:

Zygomatic width: mean 34.14 vs 37.38, R= 34.98-39.70, N= 10, SD= 1.45.

Tail-vent length: mean 353.50 vs 433, R= 410-460, N= 6, SD= 17.88.

Interorbital width: mean 8.59 vs 11.51, R= 10.65-12.22, N= 11, SD= 0.38.

Rostral width between upper canines: mean 9.69 vs 12.00, R= 11.06-12.70, N= 11, SD= 0.53.

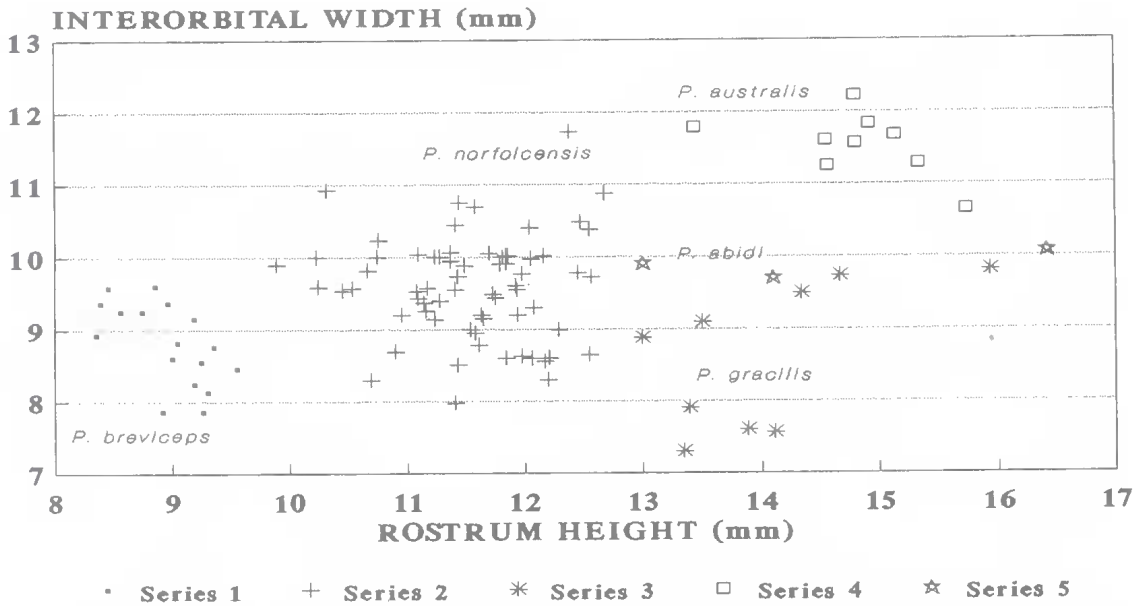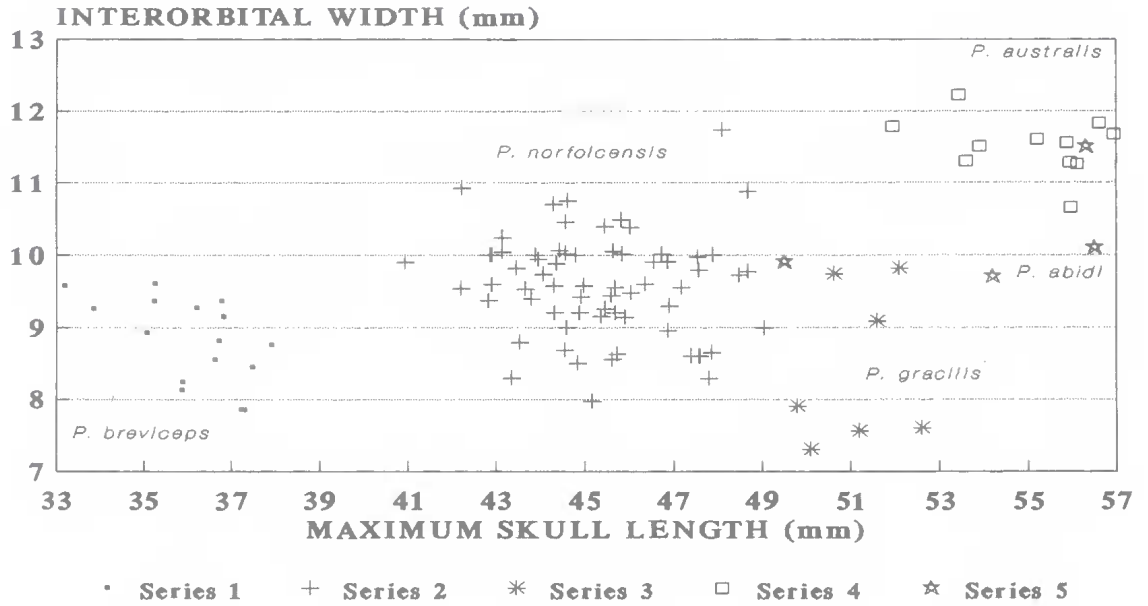Ear length: mean 31.96, R= 27-36, N= 10, SD= 2.85 vs 51.40, R= 46-56, N= 5, SD= 3.88.

FIG. 6. Bivariate plots of interorbital width against rostrum height and maximum skull length. Series 1= *P. breviceps*, Series 2= *P. norfolcensis*, Series 3= *P. gracilis*, Series 4= *P. australis*, Series 5= *P. abidi*.
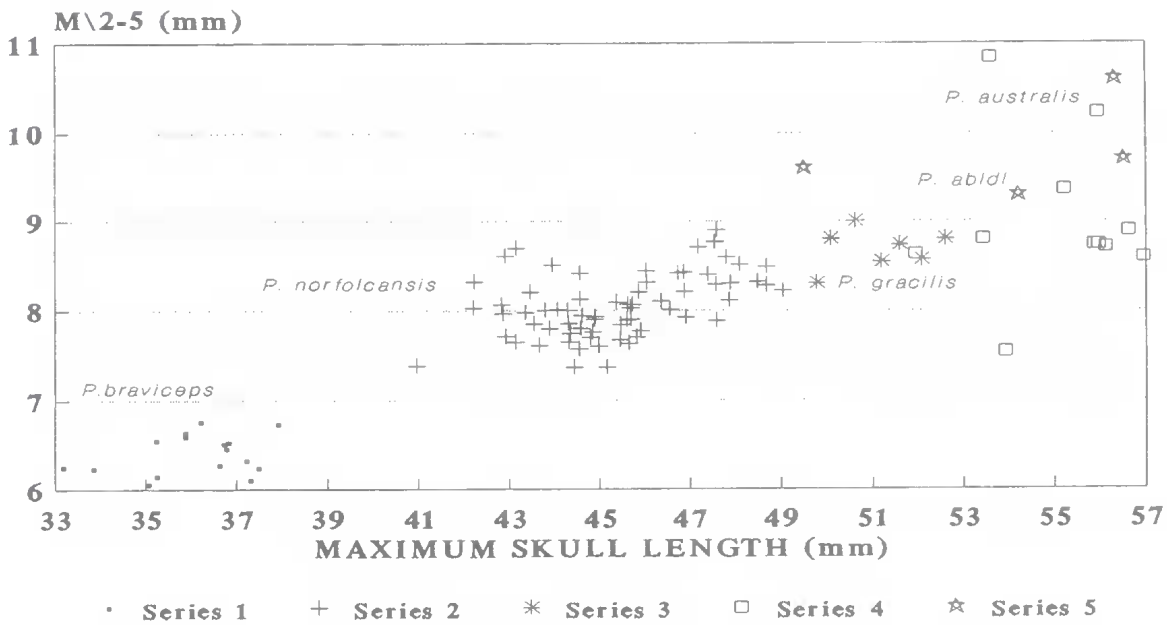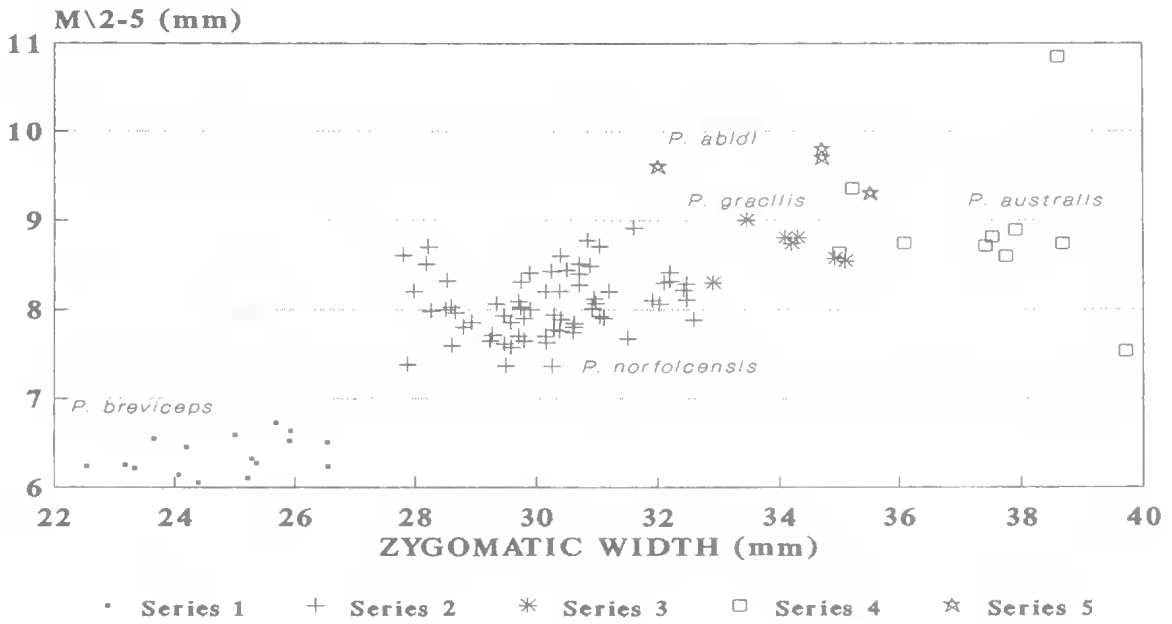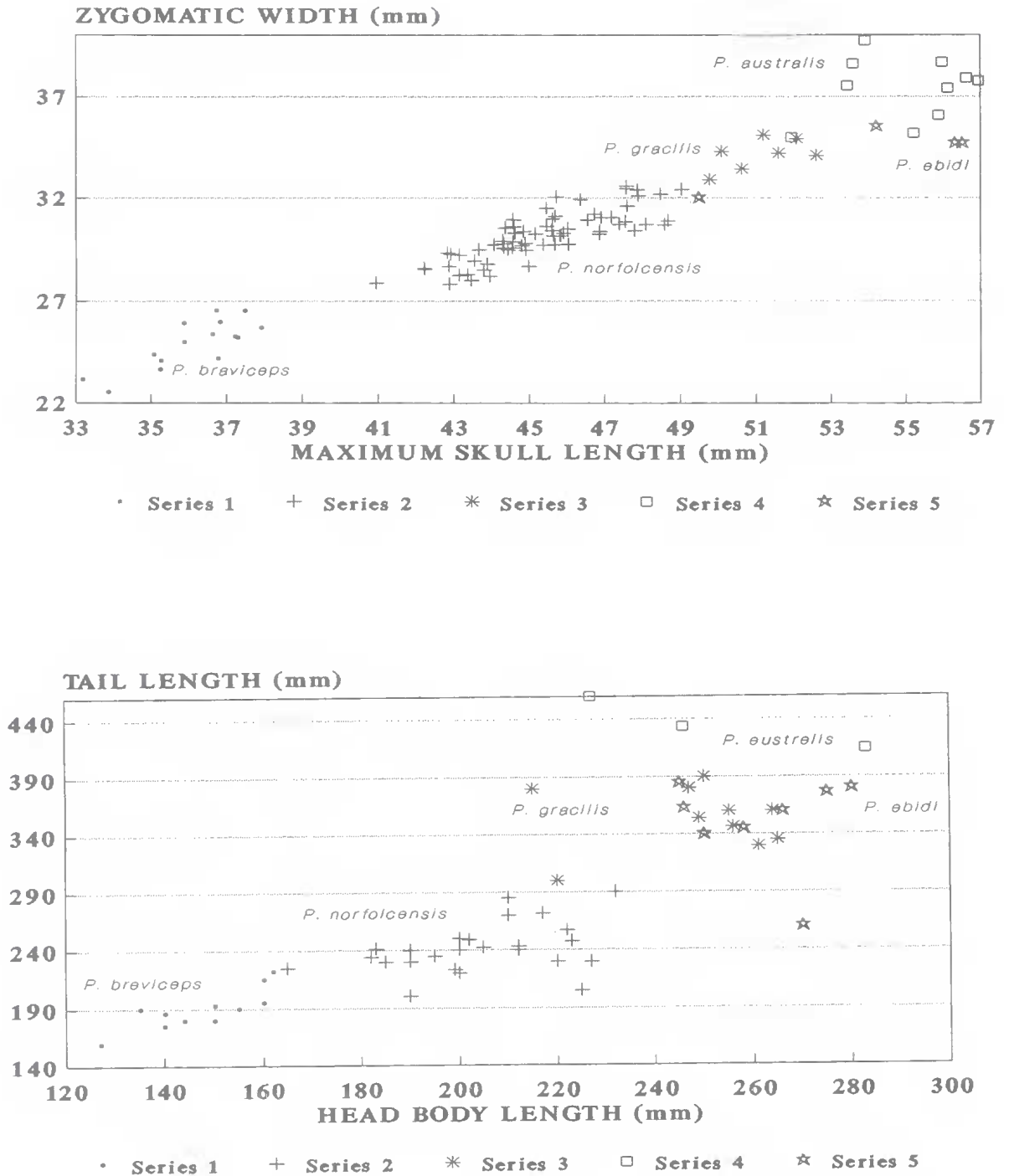
FIG. 7. Bivariate plots of upper molar row (M\2-5) against zygomatic width and maximum skull length. Series 1= *P. breviceps*, Series 2= *P. norfolcensis*, Series 3= *P. gracilis*, Series 4= *P. australis*, Series 5= *P. abidi*.

FIG. 8. Bivariate plots of zygomatic width against maximum skull length, and head body length against tail length. Series 1= *P. breviceps*, Series 2= *P. norfolcensis*, Series 3= *P. gracilis*, Series 4= *P. australis*, Series 5= *P. abidi*.
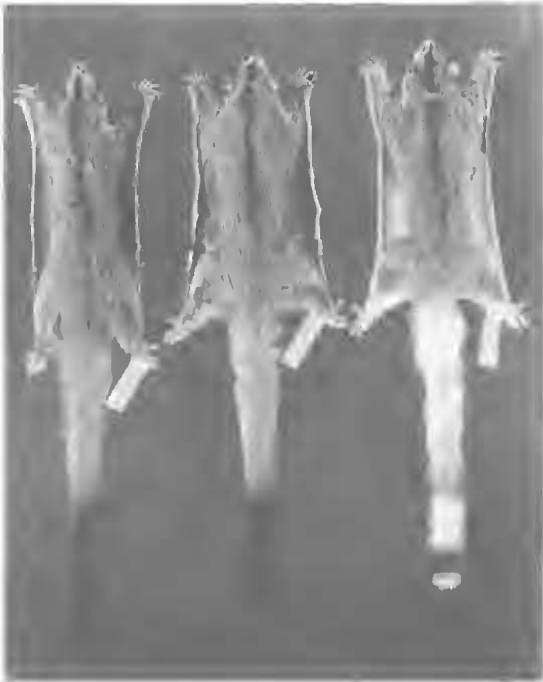
FIG. 9. Dorsal perspective of three colour morphs in *P. gracilis*. L to R, dark phase (adult male JM9014), buff phase (adult female JM9015), aberrant phase (adult female JM9016).

DESCRIPTION

Externally, this species of *Petaurus* is distinctive for its large size, long, relatively short-haired tail and buff to mahogany-brown belly (Figs 5, 9, 10). There is considerable variation in the depth of both dorsal and ventral tonings and the band of fur along the lateral anterior edge of the gliding membrane may be buff, rich orange or deep mahogany. Ventral fur (adult and sub-adult of both sexes) may be either buff, honey-yellow or deep mahogany (Figs 9, 10; Table 2).

Pelage: Colours (where capitalised after Ridgway, 1912) of the buff phase (example used JM7400) are as follows: Fuscous-Black mid-dorsal head-and-body stripe variable in width (partially depending on the 'lie' of the body fur) commencing at a point between the anterior edge of the eyes and extending posteriorly to the rump. It is 12mm wide between the ears, 5.6mm at mid-neck, 17mm at mid-shoulder blades and fading away over the rump. Fur of the mid-back (16.3mm long) with basal 14.4mm Smoke Gray, median 1.4mm either Pale Smoke Gray (off-white) or Chamois (brown-yellow), apical 0.5mm Fuscous-Black. The back therefore appears overall a patchy wash of smoky grey

(Smoke Grey) and yellowish-brown. The yellowish patches are most pronounced over the shoulders, along the flanks and over the rump. Medially thickened Fuscous-Black-tipped guard hairs are interspersed very sparsely through the fur and are 20.4mm on the mid-back and reduce to 3.6mm on the tip of the snout where they are entirely Fuscous-Black. Fur on either side of the head-stripe is Pale Smoke Gray with a yellowish-buff wash. A ring of Fuscous-Black fur encircles the eye, and fur below the eye-ring to the corner of the mouth is Pale Olive-Buff. Muzzle (delineated by the presence of mystacial vibrissae) a weak Fuscous-Black. Fuscous-Black fur encircles the dorsal posterior and ventral base of the pinna, extending forward and down to slightly posterior of the genal vibrissae. Directly anterior to the ear and posterior to the genal vibrissae, is a patch of anteriorly-directed Pale Olive-Buff fur. The pinna is virtually naked on the inner surface, and on the distal 11mm of the outer surface. The pinnae of living animals are a pink-bronze. A patch of pale Olive-Buff fur (hairs up to 8mm long) on the posterior external edge of the pinna forms a conspicuous tuft.

Dorsally, the patagium is fringed along its length by a thickly-furred band of Cream-Buff fur (hairs 3mm long). Midway between the wrist and digit 5, the apex of a triangular patch of striking Chamois-coloured fur extends in a narrowing band (to 5mm wide) posteriorly along the inner side of the outermost Cream-Buff band. More mesially, and slightly overlaying the Chamois band the patagium is coloured Sepia in a hard line 6mm wide and extending posteriorly from the wrist to the ankle. Sepia fur sparsely covers the rest of the patagium.

Ventrally, the patagium is fringed in a 5mm wide band of Clay coloured fur from the claw of digit 5 to the ankle. More mesially this band is partly overlaid by another 5mm wide band of Sepia which extends from 20mm posterior of the digit 5 claw to the ankle where its colour fades. The bulk of the patagium is then sparsely covered with 15mm long Honey-Yellow fur.

The soft ventral fur (18mm long on the belly) is Cream-Buff to Honey Yellow, but is suffused with Smoke Gray hairs on either side of the neck and around the muzzle.

Forefeet digits are thinly covered with Smoke Gray hairs. Hindfeet are more thickly covered with slightly lighter Pale Olive-Buff which contrasts with a 'mitten' of Smoke Gray over the metatarsals extending up to the inner posterior region of the thigh in a triangular stripe 23mm at

TABLE 3. Localities surveyed, spotlight cffort and arboreal mammals recorded. Mammals are grouped by locality, not by date. Fruit bat presence not recorded.*Observed on dry *E. acmemoides* ridge. # Observed at approx. 610 m. a.s.l. ▲ Site cleared Feb 1990.

SURVEY AREA		Lat.	Long.	PERIOD	SPOTLIGHT MANHOURS	ARBOREAL SPP OBSERVED (N)
1. Bluewater		19°13-14'S	146°25-30'E	May 92	8	—
2. Rollingstone	Clemant S.F. west	19°05-06'S	146°25-27'E	May 92	13	*P.breviceps* (3+1 call)
				Jun 92	2	
	Clemant S.F. east	19°04-05'S	146° 25-27'E	May 92	16.5	*P.breviceps* (1) *T.vulpecula* (3)
				Jun 92	3	
				Sep 92	13.5	
3. Paluma turnoff		18°58'-59'S	146 °17-18'E	May 92	2	—
				Jun 92	7	
4. Amos Rd- coast- Crystal Ck		18°54-57'S	146°16-17'E	May 92	8	*T.vulpecula* (1)
5. Orient Ck		18°47-48'S	146°13-14'E	Sep 92	26	*T. vulpecula* (2)
6. Ashton Ck		18°37-38'S	145°53-56'E	Jun 92	18	*P. gracilis* (3) *T. vulpecula* (8)* *P. breviceps* (1)*
7. Lannercost Ck		18°37'S	145°56-58'E	Jun 92	6	*P. gracilis* (1)
8. Wallaman Rd		18°37'S	145°52-53'E	May 91	10	—
				Mar 92	1	
9. Manor Ck		18°29'S	146°03'E	Jun 92	15	*P. breviceps* (1)
10. Elphinstone Ck		18°29'S	146°01'E	Mar 92	4	*P. gracilis* (1)
11. Porters Ck		18°26'S	146°07'E	Mar 92	9	*P. gracilis* (2)
				May 92	9	
12. Mullers Ck		18°26'S	146°07'E	May 92	12	*P. gracilis* (2)
13. Yamanie N.P. Mt Echo		18°24-25'S	145°46-47'E	Jun 86	24	*P. gracilis* (1)
				Jul 88	18	
				Mar 92	6	
14. Henrietta Holding		18°24'S	145°45'E	Oct 92	11	—
15. Gowrie Ck		18°23-24'S	145°50'E	Jul 88	12	*P. volans* (1)
16. SE of 5 mile Ck		18°20-23'S	146°03-06'E	May 92	10	—
17. SW of 5 mile Ck		18°20-23'S	146°03-06'E	May 92	28	—
18. Macalister Mts		18°17-19'S	145°57-58'E	Jul 88	70.5	*D. lumholtzi* (1) *P. herbertensis* (4) *P. breviceps* (1)
19. Ellerbeck Rd		18°14'59"S	145°58'36"	Nov 92	2	*P. breviceps* (1)
20. Hinchinbrook Is		18°14'S	146°08'E	Sep 92	16	*U. caudimaculatus* (1)
21. Baird Ck		18°12'S	145°58'E	Mar 92	2	*P. gracilis* (1)
22. Kirrima-Blencoe Falls		18°09-14'S	145°32'-38'E	Mar 92	11	*T. vulpecula* (28) # *P. volans* (26) #\ *P. peregrinus* (11) # *P. breviceps* (2)# *A. pygmaeus* (1)#
23. Edmund Kennedy N.P.		18°08-11'S	145°58-59'E	Sep 91	31.5	*P. gracilis* (2 calls) *D. trivirgata*
				Mar 92	27	
24. Dalachy Ck		18°08-09'S	145°56-57'E	Mar 92	15.5	*P. gracilis* (3) *T. vulpecula* (2) *P.breviceps* (1)
25. Murray Upper		18°08'S	145°47'E	Mar 92	3	*P. gracilis* (1)
26. North Murray		18°05-06'S	145°46-48'E	Mar 92	11	—
27. Yingalinda Beach		18°03'S	145°59'E- 146°02'E	May 91	20	*P. gracilis* (1)
				Aug 91	24	
				Nov 91	16	

TABLE 3 cont. Localities surveyed, spotlight effort and arboreal mammals recorded.

SURVEY AREA	Lat.	Long.	PERIOD	SPOTLIGHT MANHOURS	ARBOREAL SPP OBSERVED (N)
28. Barretts Lagoon to Bedford Ck	18°02-04'S	145°58-59'E	Dec 89	36	D. caudimaculata (1) D. trivirgata (2) P. breviceps (1)
			Feb 91	46	
			May 91	15.5	
			Sep 92	9	
29. ▲ Barretts Lagoon (southwest bank)	18° 02'S	145°58'E	Dec 89	115	P. gracilis (9) P. breviceps (6) D. trivirgata (1) A. pygmaeus (2)
30. Barretts Lagoon (northeast bank)	18° 02'23"S	145°58'46"E	Sep 91	1	P. gracilis (1 + 1 call)
31. Barretts Lagoon ("Ricefields")	18°01'S	145°58'E	Feb 91	110	P. gracilis (10) P. breviceps (4) D. trivirgata (1)
			May 92	68	
			Aug 91	249	
			Nov 91	18	
			Mar 92	5.5	
32. Barretts Lagoon (east)	18°01'S	145°59'E	May 91	10	P. gracilis (9 + 2 calls) P. breviceps (3) A. pygmaeus (1)
			Aug 91	17	
			Nov 91	20	
			Mar 92	5.5	
			Sep 92	9	
33. Hull R	17°58'S	146°01-02'E	Oct 92	8	P. gracilis (1)
34. Mission Beach Rd	17°55-56'S	146°00-05'E	Oct 92	23	D. trivirgata (1)
35. Graham Ra N.P.	17°18-19'S	146°01'E	Oct 92	15	—
36. S of Daintree R, Mossman	16°17-18'S	145°25-26'E	Oct 92	12	—
			TOTAL	1334	

its widest point almost to the base of the tail. A similar, but darker forearm 'stripe' (Fuscous Black) extends from the base of digit 1 along the antero-mesial region of the forearm to terminate in a 20mm wide patch at the base of the forearm.

The tail is thinly haired and approximately one-and-a-half times longer (average 147%) than the head and body length. Near its base (40mm from the body) the fur is slightly shorter dorsally (25mm) and ventrally (17mm) than laterally (33mm). 40mm from the tip of the tail the fur is even in length and slightly shorter (24mm). The distal one-third of the tail is Fuscous Black changing reasonably abruptly to honey-grey (basal 20mm Smoke Gray, apical 13mm Chamois).

Males exhibit naked, ovoid glandular patches on the crown of the head within the black head-stripe (gland approx. 9mm × 5mm) and at the base of the throat (approx. 9mm × 7mm).

Vibrissae: Approximately 16 relatively short Fuscous Black mystacial vibrissae occur on each side and measure up to 19mm long; supra-orbital vibrissae (Fuscous Black) number approx. 2 each side, genals number 2-3 (Fuscous Black) and metatarsals number 4 (Chamois).

Claws of fore and hind feet are relatively large with maximum chord length of digit 4 and 5 claws approx 9mm. Digit 4 is the longest digit of manus or pes and digit 4>5>3>2>1.

In the dark phase (Figs 9, 10), white and buff colours are replaced with deep gingers, browns or Fuscous-Black. The pattern of body stripes, tail and limb 'pennants' is as in the buff form but the median section of mid-back varies from Tawny Olive to Deep Mouse Gray (not Pale Smoke-Gray), the head may be Tawny Olive to Pale Olive Gray, the cheeks and flanks Honey Yellow to Dark Olive-Gray (not Pale Olive-Buff), and the dorsal anterior flange of the patagium Honey Yellow to Deep Olive Yellow (not Chamois). The dorsal surface of the patagium is Deep Mouse Gray, its external margin Deep Olive-Gray, ventrally the patagium is fringed in a 5mm wide band of Deep Olive-Gray fur tipped with buff (the apical 1mm) from the claw of digit 5 to the ankle. More mesially this band is partly overlaid by another 5mm wide band of Fuscous-Black which extends from 20mm posterior of the digit 5 claw to the ankle where its colour fades. The bulk of the patagium is then sparsely covered with Deep
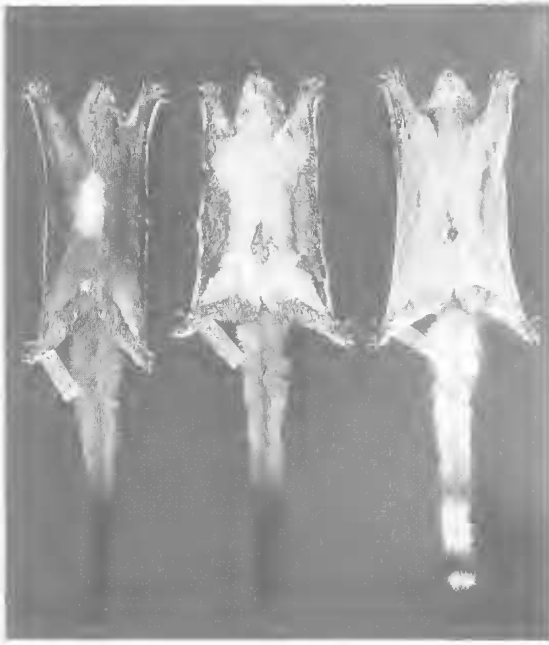
FIG. 10. Ventral perspective of three colour morphs in *P. gracilis*. L to R, dark phase (adult male JM9014), buff phase (adult female JM9015), aberrant phase (adult female JM9016).

Olive-Gray fur. Fur encircling the dorsal posterior and ventral base of the pinna, extending forward and down to slightly posterior of the genal vibrissae is Fuscous-Black. The ventral surface from throat to sternum is a Grayish Olive to Tawny Olive darkening to Sepia or Dark Olive near the belly. A small spot or streak of white fur may be present on the belly, sternum or slightly anterior to the pouch. The scrotum is buff-coloured, and hair inside the pouch Warm Sepia.

Aberrant form (Figs 9,10): JM9016 may represent an aberrant form where the ventral surface is more richly coloured with Clay Colour (orange-ochre) fur which extends around the forefeet up to the elbows, around the hind feet as far as the knees, and over the patagial edges to end along the animal's flanks . A small white patch of fur is present in the head-and-body stripe just posterior the ears. The tail is banded as follows (from the base), 11mm white, 14mm Mineral Gray, 50mm Tilleul Buff, 36mm Mineral Gray, 40mm Tilleul Buff, 57mm Mineral Gray, 26mm Fuscous (marking the proximal extent of a normal black tail-tip), 64mm Pale Olive-Buff, 40mm Fuscous-Black. Alexander (1981) illustrated an aberrant specimen, M8134, from Grafton, New South Wales similar to JM9016. He commented on the

possibility of M8134 being 'some sort of hybrid' between *P. breviceps* and *P. norfolcensis*. Given the size disparity between *P. breviceps* and *P. gracilis* and the observed intolerance of *P. gracilis* toward *P.breviceps* in the field, the likelihood of JM9016 representing a hybrid is probably remote.

Cranium and dentition: Essentially similar to *P. norfolcensis* except skull longer and much broader, with a much higher rostrum and wider ascending ramus. In spite of such consistently high values in *P. gracilis*, upper molar row lengths are not significantly longer than those of large examples of *P. norfolcensis*, and interorbital length in *P. gracilis* is significantly narrower than *P. norfolcensis* of all sizes (Figs 6-8).

Biochemical analysis: Electrophoretic allozymic analysis conducted by Colgan and Flannery (1992) showed *P. gracilis* to be genetically distinct (three fixed differences; adenylate kinase (1), glycerophosphate dehydrogenate and phosphoglucomutase in 21 loci) from *P. norfolcensis norfolcensis* (Limeburners Creek, NSW).

DISTRIBUTION
P. gracilis has been recorded only from a narrow band of medium to low woodland on Quaternary coastal alluvium and granite north of Wharps Holding (S of Herbert River, Ingham) to the Hull River, a latitudinal range of almost 80km (Fig. 1). In this band, *P. gracilis* has been found at altitudes below 90m a.s.l. with most records from between the 0-20m contours (Tables 1 and 2).

RESULTS

HABITAT
Vegetation associated with *P. gracilis* included Vegetation Types 15a (Medium Open-forest i.e. paperbark swamp), 17 (Coastal Beach Ridges and Swales), 19 (Coastal Floodplains and Piedmont slopes), 20 (Texture-contrast Soils with Impeded Drainage on Coastal Plains) and 24 (Cleared) of Tracey (1982). The appropriate Tracey vegetation type (TVT) appears with each site vegetation proforma below. The following abbreviations were used to describe the relative abundance of plant species (A-abundant, C-common, O-occasional, U-uncommon).

Sites marked thus * indicate records supplied courtesy of Queensland Forest Service. Tracey (1982) provides an overview of climate, physiography, geography and soils of the area. The Quaternary lowland coastal plains and extensive

beach ridges which typify the distribution of *P. gracilis* occur in narrow corridors up to 10km wide and 50km long between the steep ranges near the coast and the main scarp further upland. Soil types are determined by drainage; on the better-drained levees yellow friable loams predominate, and there is a progression to gleyed podzolic soils, humic gleys and acid peats as the site drainage becomes poorer. Calcareous or siliceous sands are found on the younger near-coastal ridges and podzols occur on the older ridges.

Annual rainfall is high, but widely different rainfall regimes operate and vary considerably over short distances because of local topographic changes which include the height and orientation of mountain ranges and the direction of the coastline with respect to the prevailing south-east air stream. The wide coastal plains and beach ridges show dramatic drops in rainfall from coast to foothills, e.g. Halifax 2127mm west to Upper Stone 1533mm in 45km. The relative dryness of foothills and eastern slopes may account for the apparent restriction of the glider to areas of very low elevation (below 90m a.s.l.). While foothills may receive only slightly less summer rainfall than coastal plains (Rollingstone, 19°03'S 146°24'E, Dec 220mm, Jan 416mm, Feb 344mm compared with coastal plain Euramo, 18°00'S 145°56'E Dec 167mm, Jan 597mm, Feb 652mm), dry season rainfall in foothills may be inordinately low (Rollingstone Jun 15mm, Jul 11mm, Aug 18mm, Sept 25mm contrasted with Euramo Jun 132mm, Jul 93mm, Aug 67mm, Sept 99mm). Latitudinal variation in rainfall may also be dramatic over short distances, e.g. Tully 4188mm south to Cardwell 2132mm in 40km.

SITE RECORDS (see Table 1)

Two historic records exist for which there can be no precise fix:

i. 'North of Cardwell' (de Vis 1883). No habitat information is included in the original description, and to date no Broadbent diary has been found for that period. The Edmund Kennedy National Park (NP 771) now accounts for approximately 6200ha of largely unaltered lowland coastal land immediately north of Cardwell (to the Murray River). The park contains a variety of lowland vegetation communities (all below 20m elevation) from mangroves, bulkuru swamps, paperbark forest and dry eucalypt woodland through to rainforest. Approximately 30% of this park could be considered possible habitat for *P. gracilis* (open sclerophyll forest with shrubby understorey), approximately 1% could be considered optimal habitat. The glider has recently been recorded within the park boundary. For more detailed floristics see habitat data (for sites 13 and 14) below.

ii. 'Mt Echo' (locality information on tags attached to skins JM5521, JM5522, JM5523). No specific vegetation or elevation information is available with this record and although the 1886 diary of Kendall Broadbent documents his camp on the Herbert River and his collecting efforts on the steep slopes and summit of Mt Echo, no details are given concerning where gliders were collected. The problem is further compounded by Broadbent's various references to vernaculars such as 'small flying squirrels', 'flying squirrels', and a 'large flying squirrel' in lieu of specific titles for collected examples of *Petaurus breviceps*, *P. gracilis* and *Petauroides volans*. Vegetation of the dry slopes of Mt Echo beside the Herbert R has probably changed little since Broadbent's day. At one site (18°24'52'S 145°46'13"E) the dominant species in the upper canopy (23m with 30% cover) were *Eucalyptus tereticornis* (C), *Lophostemon suaveolens* (A), *E. clarksoniana* (O) and *E. tessellaris* (O). Understorey (<5% cover) species comprised *Planchonia careya* (O) and *Pandanus* sp. (O). Ground layer (100% cover) consisted of *Imperata cylindrica*, *Mnesithea rottboellioides* (A), *Triumfetta rhomboidea* (C) and *Panicum maximum* (O). Soil was rocky, brown sandy loam. TVT 19.

Contemporary records for which more precise fixes are available (Fig. 1):

1. *Wharps Holding (18°41'18"S 146°04'25"E). Dominant species of the upper stratum (25m with <45% cover), *E. platyphylla* (U) and *Melaleuca dealbata* (A). Understorey (20% cover) composed of *L. suaveolens* (C) and *Pandanus* sp. (U). Ground layer (50% cover and heavily grazed) probably *I. cylindrica* and other grasses. This area was notable for its coarse mosaic of single species associations. Isolated clumping of single species included *M. dealbata*, *L. suaveolens*, *E. tessellaris* and *Acacia crassicarpa* with *E. platyphylla* scattered throughout. This area is renown for its protracted periods of extensive inundation during the wet season. Soil, grey loam, TVT approaching 16p. A second glider observation was made nearby (100m N) on a gently sloped rocky ridge (40m a.s.l.) where dominant species of the upper stratum (18m with <30% cover) included *E. platyphylla* (O), *L. suaveolens* (A), *E. tessellaris* (O) and *E. dolichocarpa*. The understorey (<1% cover) was com-

TABLE 4. Species, numbers, dimensions and densities of trees at four *P. gracilis* nest sites . CBH=circumference at breast height.

Nest Site	Total No. trees	Tree species	Number on grid (% of all trees)	Mean number /1000 m²	Height range (m)	Mean Ht (m), (SD),(SE)	CBH range (mm)	CBH mean, (SD),(SE)
1. Barretts Lagoon 18°01'33"S, 145 59'08"E *E.intermedia* (live) Ht 7m,CBH 780mm Surveyed 13.8.91 Fig. 11.	1204	*Eucalyptus intermedia*	31 (2.6)	17.2	3-10	7.10 (2.13) (0.69)	160-940	554.61 (224.32) (7.24)
		E. pellita	1 (0.08)	0.5	10	10.00	730	730
		Lophostemon suaveolens	26 (2.2)	14.4	3-9	6.11 (2.23)(0.09)	110-920	447.69 (254.36) (9.78)
		Acacia crassicarpa	21 (1.7)	11.7	3-8	4.76 (1.58) (0.07)	110-650	252.86 (154.89) (7.38)
		A. flavescens	3 (0.2)	1.7	3	3.00	100-130	113.33 (15.27) (5.09)
		A. pubirhachis	1 (0.08)	0.5	3	3.00	100	100
		Melaleuca viridiflora	69 (5.7)	38.3	3-8	4.23 (1.41) (0.02)	70-670	270.88 (154.01) (2.23)
		Pandanus citraceus	34 (2.8)	18.9	<1			
		Xanthorrhoea johnsonii	1018 (84.5)	565.5	<1			
2. Barretts Lagoon *Scleria* swamp 18°01'44"S 145°59'04"E *E. pellita* (live) Ht 12m,CBH 1490mm Surveyed 14.8.91 Fig. 12.	466	*E. pellita*	17 (3.6)	9.4	3-13	9.00 (4.05)(0.24)	110-1650	709.41(560.03) (32.93)
		L. suaveolens	52 (11.2)	28.9	3-14	6.79 (3.52) (0.07)	130-1590	501.35 (384.82) (7.40)
		A. crassicarpa	4 (0.9)	2.2	5-12	7.25 (3.20) (0.80)	200-460	370.00 (197.15) (49.29)
		A. flavescens	1 (0.2)	0.5	3	3.00	110	110
		M. quinquenervia	176 (37.8)	97.8	3-14	8.68 (3.65) (0.02)	110-1940	513.01 (304.86) (1.732)
		Melicope elleryana	3 (0.6)	1.7	3	3.00	100-150	120.00 (26.46) (8.82)
		Deplanchea tetraphylla	1 (0.2)	0.5	12	12.00	780	780
		P. citraceus >1m	19 (4.1)	10.5	2-10	5.89 (2.86) (0.15)	430-650	542.63 (65.22) (3.43)
		P. citraceus <1m	43 (9.2)	23.9	<1			
		Gahnia sieberiana	131 (28.1)	72.8	<3			
		X. johnsonii	18 (3.9)	10.0	<1			
		Banksia integrifolia	1 (0.2)	0.5	6	6	470	470
3. Barretts Lagoon "Ricefields" 18°01'26"S 145°58'46" E *L. suaveolens* (live) Ht 10m, CBH 1250mm Surveyed 15.8.91 Fig. 13.	690	*E.intermedia*	18 (2.6)	10.0	3-12	7.00 (2.30) (0.13)	120-840	408.89 (205.57) (11.42)
		E.pellita	37 (5.4)	20.5	3-15	6.89 (3.93) (0.11)	70-3000	589.02 (760.50) (20.55)
		L. suaveolens	73 (10.6)	40.5	3-10	5.49 (2.10) (0.03)	60-1400	375.30 (305.34) (4.18)
		M. viridiflora	6 (0.9)	1.7	3-6	4.33 (1.03) (0.17)	90-550	241.67 (149.45) (24.91)
		M. dealbata	1 (0.1)	0.5	6	6.00	300	300.00
		A. crassicarpa	11 (1.6)	6.1	3-9	6.36 (1.80) (0.16)	80-700	428.18 (200.64) (10.61)
		A. flavescens	2 (0.3)	1.1	3-4	3.5 (0.70) (0.35)	150-180	165.00 (21.21) (10.61)
		Planchonia careya	1 (0.1)	0.5	4	4.0	210	210.00
		P. citraceus >1m	15 (2.2)	8.3	2-6	3.93 (1.03) (0.07)	280-450	350.00(50.00)(3.33)
		P. citraceus <1m	272 (39.4)	151.1	<1			
		X. johnsonii	245 (35.5)	136.1	<1			
4.Barretts Lagoon 10°01'35"S 145°58'52"E Dead stag Ht 13m, CBH 1620mm Surveyed 16.8.91 Fig. 14.	680	*E. intermedia*	38 (5.6)	21.1	3-14	8.45 (3.29) (0.09)	70-1940	509.21 (370.20) (9.74)
		E. pellita	29 (4.3)	16.1	3-14	7.65 (3.99) (0.14)	50-1040	425.51 (344.78) (11.89)
		L. suaveolens	51 (7.5)	28.3	3-12	5.84 (2.65) (0.05)	90-10000	293.92 (205.76) (4.03)
		M. dealbata	2 (0.3)	1.1	2-4	7.00 (4.24) (2.120)	130-520	325.00 (275.77) (137.89)
		A. crassicarpa	33 (4.8)	18.3	3-10	6.00 (2.60) (0.08)	60-670	284.54 (188.65) (5.72)
		A. flavescens	27 (4.0)	15.0	3-12	7.15 (2.75) (0.10)	60-740	328.15 (199.19) (7.38)
		P. careya	2 (0.3)	1.1	3-4	3.50 (0.71) (0.35)	200-240	220.00 (28.28) (14.14)
		P. citraceus >1m	3 (0.4)	1.7	2-6	4.67 (2.31) (0.77)	320-490	406.67 (85.05) (28.35)
		P. citraceus <1m	84 (12.3)	46.7	<1			
		X. johnsonii	411 (60.4)	228.3				

Additional notes on nest sites of Table 4.

Understorey.

Site 1 (Fig. 11): Dry low woodland between swales with groundcover species homogeneous throughout site. 70-95% cover and dominated by *Themeda triandra* and *Leptocarpus ramosus* (both about 1 m) with smaller representation (< 10 specimens) by *Lomandra longifolia*, *Dianella caerulea*, *Melastoma affine*, *Banksia integrifolia* var. *aquilina*, *Dipodium ensifolium*, *Schoenus sparteus* and *Lindsaea ensifolia*. Regrowth (< 3 m) with 10-20% cover by *Acacia mangium*, *A. crassicarpa*, *Lophostemon suaveolens*, *E. pellita*, *M. viridiflora* and *A. pubirhachis*. Of *X. johnsonii*, (tallest 800mm), 32 with green scapes (7 with *P. gracilis* foot prints, 2 with gouges), 130 with dry seeded scapes. Site 1 sufficiently elevated to escape inundation in wet season.

Site 2 (Fig. 12): Tall teatree-razorgrass swamp with eastern edge encroaching swale and dominated by dense groundcover (90%) of *Leptocarpus ramosus*, *Blechnum indicum*, *Scleria ciliaris*, *Baumea* sp., and *Ischaemum australe* var. *villosum*. Sparce cover of *M. affine*. Southern and western quarters dominated by *S. ciliaris* and *B. indicum* to 1400mm (70-90%), *Baumea* sp. (approx 2%) and *Dichranopteris linearis* (approx 5%). The drier, more elevated western quarter dominated by *I. australe* var. *villosum* and *L. ramosus* at 400mm (approx 50%) with *Gahnia sieberiana* at 1.2m (10%), *D. linearis* at 600mm (5%) and stunted *M. quinquenervia* (2%) with *L. ramosus* at 600mm and *Erocaulon australe* at 300mm in the swale. Sparse (<1%) regenerating vegetation comprised *M. quinquenervia* in western, southern and eastern quarters with *A.crassicarpa*, *A.flavescens* and *L. suaveolens* (total 2%) in the north. *X. johnsonii* showed 4 green scapes, 4 dry seeded scapes, 1 with foot prints and 0 scarred.

Site 3 (Fig. 13): Swale and medium to low woodland. Southern half (swale) dominated by dense groundcover (75% cover) of stunted *M. quinquenervia* (5-6%) at 0.5m, *M. viridiflora* (30 specimens all < 3 m), *I. australe* var. *villosum* (80%) at 1.1 m, *Themeda triandra* (1-5%), *Leptocarpus ramosus* (5%), *Scleria polycarpa* (5%) and *Eriachne triseta* (5%). Northern half (woodland) densely covered (100%) with *I. australe* var. *villosum*, *T. triandra* and *Lomandra longifolia*, *Smilax australis* abundant and up to 4 m, *L. ensifolia* common in localised clumps, *M. affine* sparse, *D. caerulea* common, *Planchonia careya* common and up to 3 m, *M. affine* to 2m but uncommon, *Schoenus calostachyus* common. Revegetation dominated by *A. flavescens* to 3m and spaced at approximately 2 m, *A.crassicarpa* to 3m but less common. *X. johnsonii* showed 41 green scapes, 58 dry seeded scapes, 11 with foot prints and 5 scarred.

Site 4 (Fig. 14): Groundcover homogeneous throughout with *Smilax australis* rampant and up to 6 m. *L. ensifolia* common throughout, *H. actuigluma* sparse, *D. caerulea* common, *Pteridium esculentum*, *T. triandra*, *P. careya*, *Schizaea dichotoma* sparse, *Eustrephus latifolius*, *L. longifolia* common, *Clerodendrum longiflorum* var. *cunninghamii* common to 2m and often dense. *M. affine* forming clumps up to 2m high by 12m wide, *Alphatonia excelsa* sparse. Regenerating *A. flavescens* and *A. crassicarpa* to 3m common and forming 20% cover. Many dead acacias 8-10 m. *X. johnsonii* showed 80 green scapes, 131 dry seeded scapes, 51 with foot prints and 23 scarred

posed of *Planchonia careya* (O) and the ground layer (50% cover and heavily grazed) of probably *I. cylindrica* and other grasses.

2 & 3. ***Tinkle Creek** (18°39'20"S, 145°54'55"E) and ***Lannercost Creek** (18° 38'20"S, 145°54'15"E). Dominant species in the upper canopy (22m with 30% cover), *E. platyphylla* (C), *E. clarksoniana* (C), *E. tessellaris* (C) and *E. drepanophylla* (C). Understorey (30% cover) composed of *P. careya* (C) and *Xylomelum scollianum*. Ground layer (50% cover and grazed) of *Cajanus reticulata* and *Heteropogon contortus*. Soil, coarse pale sand and rocks, TVT 16p. Foothills with a gentle slope (1:10).

4. **Ashton Creek** (18°37'41"S, 145°53'57"E). Glider not seen feeding. Dominant species in the upper canopy (24m with 35% cover), *E. tereticornis* (C), *E. platyphylla* (C), *E. clarksoniana* (C) and *E. tessellaris* (C). Understorey (20% cover) composed of *P. careya* (C), *A. crassicarpa* (O), *A. mangium* (O), *L. suaveolens* (O), *Albizia canescens* (U) and *Timonius timon* (U). Ground layer (50% cover and grazed) of *Hyptis*

capitata, *I. cylindrica* and other grasses. Soil, brown sandy loam, TVT 20.

18° 37'26"S 145° 54'12"E. Gliders feeding in flowering *E. tereticornis*. Dominant species in the upper canopy (20m with 35% cover), *E. tereticornis* (C), *L. suaveolens* (A), *E. clarksoniana* (O), *E. tessellaris* (O), *A. crassicarpa* (O) and *Acacia mangium* (O). Understorey (<5% cover) of *P. careya* (O). Ground layer (30% cover and heavily grazed) of unidentified grasses. Soil, grey-brown sandy loam, TVT 20.

5. **Lannercost Creek** (18°37'13"S, 145°56'44"E) (tongue of natural vegetation between exotic pine plantation and creek). Glider not seen feeding. Dominant species in the upper canopy (30m with 30% cover), *E. drepanophylla* (C), *E. dolichocarpa* (O), *L. suaveolens* (O), *E. tessellaris* (O), *E. platyphylla* (U) and *M. leucadendron* (C) on the creek. Understorey (10% cover) composed of *P. careya*, *Acacia crassicarpa*, *A. mangium* (creek), *Carallia brachiata* and *Dillenia alata*. Ground layer (60% cover and heavily grazed) of probably *I. cylindrica* and other un-

identified grasses. Soil, grey-brown loam, TVT 20.

6. **Elphinstone Creek** (18°29'42"S, 146°01' 26"E) (isolated *E. clarksoniana* on edge of cane field with remnant creek vegetation). Glider feeding on *E. clarksoniana* blossom. Dominant species in the upper canopy (20m with 30% cover), *L. suaveolens* (C), *E. platyphylla* (C) and *E. clarksoniana* (C). Understorey (<10% cover) composed of *P. careya* (C) and *A. crassicarpa* (C). Ground layer (80% cover) of *I. cylindrica* and *Themeda triandra*. Soil, grey-brown sandy loam, TVT 19.

7. **Porters Creek** (18°26'57"S, 146°07'35"E). Glider feeding on blossom of *E. pellita*. Gully with 20m buffer zone, bordered both sides by exotic pine plantation. Dominant species of the upper stratum (25m with 50% cover), *E. intermedia, E. pellita*. Understorey (30% cover) composed of *Casuarina torulosa* (C, almost forming canopy), *A. flavescens* (C), *A. crassicarpa* (O), *X. scottianum* (O), *A. mangium* (O), *P. careya* (C) and *Persoonia falcata* (O). Ground layer (60% cover) of *T. triandra, Pteridium esculentum, Lomandra longifolia* (C), *Mnesithea rottboellioides* (C). Soil, brown, sandy loam, TVT 16f (without *Syncarpia glomulifera* and *Banksia compar*).

18°26'47"S, 146°07'17"E. Glider not seen feeding. Dominant species of the upper stratum (25m with 50% cover), *E. clarksoniana* (C), *E. platyphylla* (C) and *Lophostemon suaveolens* (C). Understorey (20% cover) composed of *A. flavescens* (A) and *A. mangium* (O). Ground layer (60% cover) of *H. triticeus* (O), *T. triandra* (C) and *I. cylindrica* (A). Soil, grey-brown, sandy loam, TVT 19.

8. **Mullers Creek** (18°26'13"S, 146°07'15"E). Gliders not seen feeding, site logged and thinned out. Dominant species of the upper stratum (20m with 30% cover), *E. clarksoniana* (C), *E. platyphylla* (C) *L. suaveolens* (C), *E. tessellaris* (O), *Melaleuca dealbata* (O), and *Albizia canescens* (O). Understorey (<5% cover) composed of young *M. dealbata*. Ground layer (80% cover) of *T. triandra* (C) and *I. cylindrica* (A). Soil, grey-brown loam, TVT 19.

9. **Lumholtz National Park** (18°24'30"S, 145° 46'10"E (rainforest transition site by the Herbert R). Glider feeding on *Melicope elleryana* blossom. Dominant species in the upper canopy (22m with 50% cover), *E. tereticornis* (C), *M. elleryana* (O), *L. suaveolens* (C), *Aleurites moluccana* (O), Lauraceae sp. (O), and *E. torelliana*.

Understorey (40% cover) composed of *Mallotus philippinensis* (O), *Macaranga tanarius* (O), *Aphananthe philippinensis* (O), and *Lantana camara* (O). Ground layer (10% cover) of *Calamus caryotoides* and *Triumfetta rhomboidea*. Soil, brown sandy loam, TVT 19.

10. *****Cement Creek** (18°23'55"S, 146°05' 57"E). Site not surveyed.

11. **Kennedy Valley** (18°13'31"S, 145°55' 23"E). Site presumed. Closest woodland stand to location of specimen snared on barbed-wire fence. Dominant species of the upper stratum (22m with 40% cover), *E. tereticornis* (C), *E. pellita* (C), *E. drepanophylla* (C), *E. clarksoniana* (O), *Acacia mangium* (C) and *E. tessellaris* (U). Understorey (30% cover) composed of *A. flavescens* (C), *Pandanus* sp.(O), *Guioa acutifolia* (O), *Breynia cernua* (O) and *L. camara* (C). Ground layer (40% cover) of *T. triandra* (C) and *I. cylindrica* (A). Soil, brown loam, TVT 20.

12. **Baird Creek** (18°12'11"S, 145°58'17"E). Glider feeding on *E. tereticornis* blossom. Dominant species of the upper canopy (25m with 40% cover), *E. tereticornis* (C), *E. clarksoniana* (C),

FIG. 11. Vegetation surrounding Nest Site 1 (of Table 4), Barretts Lagoon. Den tree is arrowed.

FIG 12. Vegetation surrounding Nest Site 2 (of Table 4), Barretts Lagoon. Den tree is arrowed.

A. mangium (C), *E. tessellaris* (O), *Melaleuca dealbata* (O) and *Melicope elleryana* (O). Understorey (50% cover) composed of *Alphitonia excelsa* (C), *Glochidion* ?*lobocarpum* (C), *B. cernua* (C), *Acacia flavescens* (C), *Polyscias elegans* (C) and *Planchonia careya* (O). Ground layer (<5% cover) of *Alpinia caerulea* (U) and *I. cylindrica* (U). Soil, grey-brown loam, TVT 19.

13. **Edmund Kennedy National Park** (18° 12'04"S, 145°59'14"E). Glider not seen, call only recorded. Dominant species of the upper canopy (25m with 45% cover), *E. tereticornis* (C), *Acacia mangium* (C), *Lophostemon suaveolens* (C), *E. tessellaris* (U), *Melaleuca dealbata* (O) and *E. intermedia* (O). Understorey (30% cover) composed of *Alphitonia excelsa* (O), *G.* ?*lobocarpum* (C), *A. crassicarpa* (C), *P. elegans* (C), *D. alata* (C) and *Pandanus* sp.(O). Ground layer (30% cover) of *I. cylindrica* (A), *Pteridium esculentum* (O), *T. triandra* (O), *Cycas media* (U), *Heteropogon* ?*triticeus*, with *Cymbidium madidum*, *Platycorys hillii* and *Smilax australis* (C). Soil, grey sand, TVT 19.

18°08'43"S, 145°57'50"E. Although this glider was recorded east of (and hence inside) the Edmund Kennedy National Park fence line, the site does not actually occur within the National Park. The fence does not accurately reflect the gazetted east-west boundary. Glider not seen, call only recorded. Dominant species of the upper canopy (20m with 35% cover), *E. pellita* (A), *E. intermedia* (C), *L. suaveolens* (O) and *Deplanchea tetraphylla* (U). Understorey (30% cover) composed of *A. flavescens* (C), *A. crassicarpa* (C) and *Dillenia alata* (O). Ground layer (40% cover) of *Melastoma affine* (C), *Gahnia sieberiana* (O) and *Scleria ciliaris* (A). Soil, grey sandy loam, TVT 19.

Glider moved from this site into adjacent tea-tree swamp where the dominant species of the upper canopy (15m with 50% cover) was *Melaleuca quinquenervia*. Ground layer (95% cover) of *Melastoma affine* (C), *G. sieberiana* (O), *A. pubirhachis* (C), *Rhynchospora* sp. (C), *Schoenus* ?*melanocephalus* (C), *Lycopodium cernuum* (O), *Leptocarpus ramosus* (A), *Eriocaulon* sp. (A), *Ischmaeum* sp. (C) with *Drosera spathulata*, *Myrmecodia beccarii* and *Dischidia nummularia*. Soil, grey sandy loam, TVT 15a.

14. **Dalachy Creek** (18°09'26"S, 145°57' 26"E). Glider feeding on flowering *E.clarksoniana* in cleared paddock. Vegetation proforma of closest adjacent site (creek community). Dominant species of the upper canopy (20m with 80% cover), *A.mangium* (C), *A. aulacocarpa* (C), *Lo-*

phostemon suaveolens (C), *Tristaniopsis exiliflora* (C), *Eucalyptus intermedia* (U). Understorey (30% cover) composed of *Alstonia muelleri*, *Polyscias elegans* and *P. australiana*. Ground layer (<1% cover) of *Piper novaehollandiae*, *Lygerdum* sp., *Tetracera nordtiana* and *Lomandra hystrix*. Soil, brown loam, TVT 24 (cleared near TVT 1a).

18°08'51"S, 145°57'40"E. Glider feeding on flowering *E. pellita*. Dominant species of the upper canopy (20m with 30% cover), *E. pellita* (C). Understorey (40% cover) composed of *Lophostemon suaveolens* (C), *Acacia flavescens* (C), *A. crassicarpa* (C), *Dillenia alata* (O), *Pandanus* sp. (C) and *Melaleuca quinquenervia* (C). Ground layer (30% cover) of *Scleria ciliaris* (A) and *Blechnum indicum* with *Dendrobium smiliae* and *Drynaria rigidula*. Soil, grey-brown sandy loam, TVT 19.

15. **Murray Upper** (18°08'38"S, 145°47' 54"E). Rainforest transition site, gully with 20m buffer zone, bordered both sides by pine plantations, glider not recorded feeding. Dominant species in the upper canopy (20m with 40% cover), *E. pellita* (C), *E. clarksoniana* (C), *A. mangium* (C), *E. tessellaris* (C) and *L. suaveolens* (C). Understorey (70% cover) composed of *A. flavescens* (C), *Guioa acutifolia* (O), *Scolopia braunii* (C), *Timonius timon* (C), *Dillenia alata* (C), *Rubus moluccanus* (C) and *Polyscias australiana* (C). Ground layer (<2% cover) of *Smilax australis* (C), *Hysperpalaurina* sp. (C) and *Lomandra longifolia*. Soil, brown sand, TVT 19 .

16. **Bilyana** (18°07'S, 145°56'E). Mounted specimen in private collection of T. Marsilio for which the only collection details (from card attached to specimen) are as follows: 'Fly Squerrel was killid in falling tree in front of Joe Ottone while Alec was clearing line for El. Power. at Bilianna on Bluff Road. 15 ?years ago'. TVT 24 with remnants of 19.

17. *****Murray Upper** (18°06'30"S, 145°49' 40"E). Dominant species of the upper canopy (25m with 40%cover), *E. tereticornis* (C), *A. mangium* (C), *E. tessellaris* (O), *M. dealbata* (O), *E. clarksoniana* (C) and *Melicope elleryana* (O). Understorey (50% cover) composed of *Alphitonia excelsa* (C), *Glochidion* ?*lobocarpum* (C), *A. flavescens* (C), *Polyscias elegans* (C), *Breynia cernua* (C) and *Planchonia careya*. Ground layer (<5% cover) of *I. cylindrica* (U) and *Alpinia caerulea* (U). Soil, grey-brown sand, TVT 19.

18. **Yingalinda Beach** (18°03'18"S, 146°01' 37"E). Glider recorded in *E. intermedia*. Dominant species in the upper canopy (35m with 35%

cover), *E. intermedia* (C) and *L. suaveolens* (C). Understorey (40% cover) composed of *A. flavescens* (A), *A. crassicarpa* (A), *Polyscias elegans* (O), *Alstonia muelleri* (O), *Canarium australiana* (O), *Deplanchea tetraphylla* (O) and *Planchonia careya*. Ground layer (20% cover) of *Scleria sphaolata* (C), *Pteridium esculentum* (C), *I. cylindrica* (C) and *Xanthorrhoea johnsonii* (O) with *Smilax australis, Eria fitzalanii, Dendrobium smilliae* and *Cymbidium madidum*. Soil, grey sand, TVT 17.

19. **Barretts Lagoon**. (i) South western bank (18° 02'31"S, 145° 58'36"E). Gliders recorded feeding on flowering *Eucalyptus tessellaris*. Site cleared Feb 1990. Prior to that the dominant species in the upper canopy (35 m) were *E. pellita, E. intermedia, Acacia mangium, E. tessellaris, E. tereticornis* and *L. suaveolens*. Understorey (9m and 80% cover) composed of regenerating *A. flavescens, Planchonia careya, A. crassicarpa, Melastoma affine*. Ground layer (20% cover and grazed) of *I. cylindrica* and *Themeda triandra, S. australis* and *Lomandra longifolia*. Soil, grey sand, TVT 24 with remnants of 17.

(ii) North eastern bank (18°02'22-23"S, 145°58'52"E). Gliders recorded feeding and heard grunting in flowering *E. tereticornis*. Remnant vegetation along immediate edge of Barretts Lagoon. Isolated specimens (to 30m) of *A. mangium, E. tessellaris , L. suaveolens, M. leucadendron* and *M. dealbata*. TVT 24.

(iii) 'Rice Fields' (18°01'26"S, 145°58'46"E). Gliders feeding in *E. pellita, E. intermedia, L. suaveolens, X. johnsonii*. See detailed vegetation analysis 'Nest site 3', Table 4. TVT 17.

(iv) East (18°01'33"S, 145°59'34"E). Gliders feeding in *X. johnsonii* and *M. dealbata*. Dominant species in the upper canopy (20m with 50% cover), *E. pellita* (C), *E. intermedia* (C), *L. suaveolens* (C), *A. crassicarpa* (C), *M. dealbata* (O), *Deplanchea tetraphylla* (U). Understorey (30% cover) composed of *A. flavescens* (C), *M. viridiflora* (C), *Banksia integrifolia* var. *aquilina* (U), *Casuarina littoralis* (C) and *Pandanus* sp. Ground layer (40% cover) of *T. triandra* (C), *L. longifolia* (C), *Lindsaea ensifolia* (A), *Leptocarpus ramosus* (A) and *X. johnsonii* (A). In wetter gullies at base of swales, dominant canopy species (18-20m with 50% cover) changed to *E. pellita* (A), *Lophostemon suaveolens* (A) and *A. mangium* with an understorey (15% cover) of *A. flavescens* (O), *A. crassicarpa* (O), *Pandanus* sp.(O) and *Dillenia alata*. Ground layer (30% cover) of *Gonocarpus ?acanthocarpus* (C), *Lindsaea ensifolia* (C), *Dicranthopteris linearis* (O),

Melastoma affine (C), *Eriocaulon* sp., *Scleria laevis* (C), *Ishmaeum australe* (A), *Flagellaria indica* (O) with *Eria fitzalanii* and *Dendrobium smilliae*. Soil, dark drown sandy loam, TVT 17.

20. **Hull River** (17°58'29"S, 146°02'02"E). Glider feeding in *E. intermedia*. Dominant species of the upper stratum (30m with 40% cover), *Eucalyptus intermedia* (C), *E. pellita* (A), *A. mangium* (C), *Lophostemon suaveolens* (O) and *Deplanchea tetraphylla* (O). Understorey (70% cover) composed of *Davidsonia pruriens* (C), *Polyscias australiana* (C), *A. muelleri* (C), *Dillenia alata* (O), *Wilkiea nuegeliana* (C), *Rhodomyrtus* sp., *Pandanus* sp., *Syzygium wilsonii, Lepidozamia hopei,* and *A. flavescens* (A). Ground layer (<10% cover) of *Calamus caryotoides, C. moti, Smilax australis, F. indica, Lygopodium* sp., with *Eria fitzalanii, Dendrobium smilliae, Cymbidium madidum* and *Platycorys hillii*. Soil, brown sand to sandy loam, TVT 17 adjacent to TVT 15a.

SPOTLIGHTING

Spotlighting surveys for *P. gracilis* were conducted at a number of sites (Table 3). The species was recorded at 16 of the 36 localities and represented a total of 1334 manhours of observation. In habitats supporting *P. gracilis*, the most commonly observed arboreal marsupial assemblage comprised *P. gracilis, Dactylopsila trivirgata, P. breviceps* and *Acrobates pygmaeus*. The presence of this group of exudivores and insectivores and the obvious absence of such foliovores as *Trichosurus vulpecula, Pseudocheirus peregrinus, Petauroides volans* and *Phascolarctos cinereus* may have been a reflection of possible nutritional deficiency in vegetation of the coastal alluvium, however this was not addressed in the study.

Trichosurus vulpecula was extremely rare in habitat considered optimal for *P. gracilis*. Only 1 specimen of the brushtail was recorded near such habitat (Dalachy Creek) and at that site *T. vulpecula* was recorded from a tree isolated in improved (fertilised) pasture. Where *T. vulpecula* occured commonly with *P. gracilis* (e.g. Wharps Holding) the habitat was considered marginal or poor for the glider.

BIOCLIM PREDICTION

A climate profile (Table 5) was generated by the BIOCLIM prediction system (see Nix & Switzer, 1991) after completion of field surveys. Using core predictions [geographic points matching all 28 climatic values (7 for radiation, 7 for

temperature, 7 for precipitation and 7 for moisture index) between the 5% and 95% values (the 90 percentile range) in the climate profile] the presence of *P. gracilis* was predicted beyond that area encompassed by the field results presented in Table 1 only on the north western tip of Hinchinbrook Is. (Fig. 15). Soils of the north western tip developed in situ largely from massive rhyolitic to dacitic volcanics and to a much lesser extent riebeckite granite near Scraggy Point. The north western lowland woodland communities there do not reflect a mirror image of the woodlands of the Coastal Floodplains and Piedmont Slopes (TVT 19) across the Hinchinbrook Channel on the mainland. Many potential sites (TVT 13e, 15b) appeared to be losing their identity under the encroachment of rainforest species, and drier forest types tended to be dominated by *Eucalyptus clohesiana* which grew from near sea level to well above the 100m contour. To date *P. gracilis* has not been recorded from *E. clohesiana*. In Sept 1992 two nights were spent surveying in woodland slopes supporting *E. intermedia*, *E. clohesiana*, *E. tessellaris*, *E. acmenoides*, *Melaleuca leucodendron*, *Pandanus* sp. and *Xanthorrhoea johnsonii* (Table 3) without success. Hinchinbrook Is. should be resurveyed for *P. gracilis*.

Using marginal predictions (all 28 climate values falling within the total range in the climate profile) *P. gracilis* was again only predicted to occur inside the core area plotted for the north west tip of Hinchinbrook Is.

TRAPPING

A total of 721 trapnights resulted in the capture of one *P. breviceps* from degraded habitat being cleared at Barretts Lagoon (16 Feb 1991). No *P. gracilis* were collected by this method in spite of the trapping program being conducted under the on-site advice of field researchers skilled at capturing other petaurids such as *P. breviceps*, *P. australis* and *P. norfolcensis*. The degree of difficulty in trapping *P. gracilis* by traditional methods greatly impinges on the understanding of its social organisation which is fundamental to the process of estimating its population density.

ARTIFICIAL HOLLOWS

Two sub-adult female *P.gracilis* (ear tagged T4027, T4028) were caught together in 'nestbox' No. 8 on 10 May 1991. No other *P. gracilis* were trapped by this method but other individuals were known to use the tubes e.g. radio-tagged adult male T4030 was recorded once (7 Aug 1991) in 'nestbox' 12, and an unmarked adult male (pos-

sibly T4030) escaped from 'nestbox' 27 before the entrance could be reached and plugged (4 Aug 1991). Subadult female T4028 used 'nestbox' 12 and 13 on 5 days during the period 11-19 May 1991. Tubes were more frequently inhabited by Brown Tree-snakes (*Boiga irregularis*), Green Tree Ants (*Oecophylla smaragdina*) and less frequently by Sugar Gliders (*P.breviceps*) (adult male and female, 'nestbox' 14, 25 May 1992; group in 'nestbox' 7 (east), 8 Oct 1992).

HOME RANGE DETERMINATION

Shortcomings associated with this part of the study are referred to under 'Methods'. Results of home range analysis and plots of dens appear in Figs 16-19. The 95% isopleth of the harmonic mean distance minimum gave a value of 23.01ha for adult female T4026 (110 fixes), 9.04ha for sub-adult female T4027 (36 fixes) and 13.86ha for sub-adult female T4028 (36 fixes). These results should be taken as preliminary and minimal as the plots indicate that the curves have not quite asymptoted (see Quin et al., 1992; Goldingay, 1992). Areas estimated using the miminum convex polygon (MCP) were 18.65, 16.48 and 10.96ha respectively. Overlap is shown in Fig. 19. Possible underestimation of home range size could be partly or wholly offset by patches of treeless swale included in the estimates. Sub-adults T4027 and T4028 may have been dispersing offspring of T4026. Insufficient fixes were taken of adult male T4030 (who dislodged his transmitter after 3 nights) or female T4031 (for which den fixes only were taken) to allow estimation of home ranges. However, male T4030 was known to have moved between the home range of adult female T4026 and one of the dens of adult female T4031 (see 'Reproduction' and Fig. 19). Serial den use (Kehl & Boorsboom, 1984) was noted between adult female T4026 and sub-adult female T4028, adult male T4030 and sub-adult female T4028 . Conjoint den use was noted between adult male T4030 and adult female T4026, adult male T4030 and adult female T4031, and between the two sub-adult females T4027 and T4028.

REPRODUCTION

Petaurus gracilis appears to give birth in the spring, although this pattern is complicated by the record of hairless young in the pouch of a female collected in mid-February and an observed September copulation involving a female known to be carrying two hairless pouch young.

Two adult females captured 5 and 9 Aug 1991

FIG. 13. Vegetation surrounding Nest Site 3 (of Table 4), Barretts Lagoon. Den tree is arrowed.

(T4026 and T4031 respectively) each carried two hairless pouch young. Young measured approx 35mm crown to cloaca. Females resisted attempts to examine pouch young by contracting muscles surrounding the pouch opening. By 26 Nov 1991 young of T4026 [T4032 (M) and T4033 (F)] weighed 65g and 69g (respectively) (see Table 2 and Fig. 20) and the pouch of T4026 was noted to be divided longitudinal into two halves by a thin septum (see Calaby, 1966 for description in *P. australis*). The right pouch side was thinly covered with long ginger-brown hairs and the left contained two elongated nipples, each 6mm long. Adult female T4031 was not recaptured. The pouch of adult female JM7290 collected 14 Feb 1973 contained two hairless young. The pouch of female JM8549 (which died ensnared on a barbed wire fence Oct 1990) contained one newly furred young JM8550 (43g). The right posterior corner of the pouch contained well developed mammary tissue, anterior to which (close to the body) was

a covering of long ginger hair. The single nipple measured 11mm.

The following copulatory behaviour was noted between female T4026 and male T4030 (both captured in *Lophostemon suaveolens* den, nest site 3 of Table 4, Sept 5 1991) at a time when female T4026 was carrying 2 hairless pouch young. Observations on 7 Sept 1991 commenced at 1900hrs with female motionless in *L. suaveolens* close to den. At 2030hrs, male T4030 appeared in tree 7 metres away from the tree in which the female was sitting. Both remained motionless until 2100hrs. The male then produced a soft but hoarse call resembling 'chew-chew-chew-chew' at which the female made immediate efforts to join him (but was interrupted by noise from observers on the ground). At 2226hrs the male glided to the female's tree. The female appeared to sniff and lick the male's rump (probably applying male scent as observed in *P. australis* by Henry & Craig, 1984; Russell, 1984) and followed him up the trunk to sit together in the canopy. The female then glided to a nearby large *E. pellita*, was followed by the male and the two remained motionless, 'curled up' around one another in the canopy until 0040hrs. The female then leapt to a nearby tree and was followed closely by the male. From 0057hrs to 0155hrs the two remained motionless in a 'ball' whereupon the male lunged at the female and the two copulated until 0217hrs. During copulation male and female adopted a vertical, head-down position on the trunk with the female's head pushed against an ant plant (*Myrmecodia beccarii*). The male thrust intermittently, grasping the female's dorsum in a position not unlike that adopted by young back-riding gliders newly emerged from the pouch. A neck bite was maintained by the male until the two separated, whereupon the male licked and groomed his penis. The female leapt to a nearby *E. pellita*, was followed by the male and the two sat closely and motionless until 0400hrs whereupon the female made bursts of 'glide-and-freeze' (thought not to be induced by the presence of observers) toward a den which was some way off and reached by 0545hrs. The male had lost interest in the female by 0400hrs and moved elsewhere. The male did not share the den occupied by female adult T4026, but shared an *E. intermedia* den occupied by another adult female, T4031 (with pouch young). This den could be reached over a minimum distance of approx 1.5km from where T4026 and T4030 separated.

The following night (8 Aug 1991) observation commenced with female T4026 at 1830hrs. At

TABLE 5. BIOCLIM climate profile for *Petaurus gracilis* in tropical north Queensland based on all Queensland Museum records and observations. Temperature (°C); precipitation (mm); radiation (MJ/m²/day); moisture index [0 (moisture totally limiting to growth) -1 (moisture non-limiting to growth)]. Seasonality (coefficient of variance for 12 monthly values as %).

CLIMATE PARAMETER	Min	Percentile		Max
		5	95	
Annual mean temperature	23.78	23.80	23.94	23.95
Coldest month mean minimum temperature	12.73	12.80	14.09	14.09
Warmest month mean minimum temperature	31.77	31.81	32.69	32.74
Annual range (mean max-mean min temperature)	17.67	17.71	19.89	20.01
Wettest quarter mean temperature	26.65	26.68	26.96	26.97
Driest quarter mean temperature	20.00	20.12	22.22	22.30
Seasonality (coefficient of variance)	11.87	11.90	13.04	13.08
Annual mean rainfall	1528.76	1572.11	3176.25	3262.96
Wettest month mean rainfall	345.24	352.32	628.63	628.63
Driest month mean rainfall	14.48	20.60	69.54	76.66
Annual range (wettest month-driest month)	323.59	331.48	557.40	560.36
Wettest quarter mean rainfall	1012.90	1033.28	1828.06	1828.06
Driest quarter mean rainfall	54.84	60.89	230.45	236.50
Seasonality (coefficient of variance)	80.63	83.05	104.24	104.85
Annual mean daily solar radiation	18.81	18.90	19.69	19.72
Highest monthly mean daily solar radiation	24.92	24.97	25.41	25.42
Lowest monthly mean daily solar radiation	13.46	13.57	14.52	14.56
Annual range of monthly mean daily solar radiation	10.66	10.74	11.14	11.47
Wettest quarter mean daily solar radiation	19.76	19.76	20.10	20.10
Driest quarter mean daily solar radiation	16.06	16.27	20.07	20.21
Seasonality (coefficient of variance)	17.84	18.12	19.79	20.63
Annual mean moisture index	0.63	0.64	0.92	0.92
Wettest month mean moisture index	1.00	1.00	1.00	1.00
Driest month mean moisture index	0.15	0.16	0.54	0.59
Annual range (wettest-driest month)	0.41	0.46	0.85	0.85
Wettest quarter mean moisture index	0.98	0.98	1.00	1.00
Driest quarter mean moisture index	0.25	0.31	0.86	0.87
Seasonality (coefficient of variance)	15.97	17.33	55.37	56.72

1930hrs the female began moving between trees with apparent resolve only to sit 'frozen' for extended periods then move off in the same manner. Male T4030 appeared in a nearby tree at 2318hrs. The female made soft 'chee-chee-chee-chee' calls which brought the male into her tree. The two sat closely until 0200hrs (when observations were abandoned). The pair did not share a daytime den.

The next night (9 Aug 1991) the same pair were noted consorting (only) from 2305-0100hrs. Observations continued to 15 Aug 1991 but the pair were not seen to consort again.

DENNING (see Table 4)

A total of 19 dens were recorded at Barretts Lagoon (see Figs 16-19). These varied from a dead stag of undetermined species (13m) to living examples of *E. intermedia* (8), *L. suaveolens* (2), *M. quinquenervia* (2), and *E. pellita* (6) up to 27m in height (Figs 11-14). In tall trees it was usually impossible to determine either the den entrance or the den position inside the trunk. In two cases (sites 1 and 3, Table 4), both were known. At site 1 (Figs 11 and 21) the den was made in a 7m living *E. intermedia*. The 50mm entrance hole was 5.8m above ground, the nest cavity approx. 200mm dia. and the nest of dried leaves approx 3m below the entrance. At site 3 (Figs 13 and 22) The den was made in a 10m living *L. suaveolens*. The 45mm entrance hole was 3.8m above ground, the nest

FIG. 14. Vegetation surrounding Nest Site 4 (of Table 4), Barretts Lagoon. Den tree is arrowed.

cavity approx. 250mm diameter and the nest of dried leaves approx. 50cm below the entrance.

There was no apparent shortage of hollow limbs and termite-ravaged trunks in the woodland habitat occupied by *P. gracilis* and while individual gliders showed preference for certain dens they regularly moved nests and used a variety of widely separated dens through their home range (Figs 16-19), e.g. in the period 10-20 May 1991, adult female T4026 used the 'favoured' nest (nest site 3 of Table 4) on 4 of those days and 7 different dens on the seven remaining days. This female was recorded using a total of 10 different dens.

In addition, gliders familiarised themselves with the mature trees of their home range and spent considerable time exploring hollows and holes in trees other than those known to contain dens. In one case, on consecutive nights, female T4026 descended to investigate a large, long, burnt-out log lying on the forest floor. On both

nights the end of the log was entered at ground level and the glider crawled inside to finally peer out a ground-level pophole for approx 30min before returning to the trees. (On investigation, the inside of the log was found to contain crumbled charcoal, soil and remains of goanna skin, some Echidna quills and some patches of pungently smelling possum fur (? *Dactylopsila trivirgata*).

Nests in dens consisted of a thick mat of eucalypt leaves. Animals were not observed collecting or carrying these.

VOCALISATION

Petaurus gracilis was quiet and difficult to locate by calls. The most commonly heard call was a deep, nasal, coarse grunt 'na-when, na-when'. It was not always possible to determine the sex of animals making this call, but those that were sexed were males. The call was sometimes made in response to the play-back defense gurgle ('urga-urga-urga', common to other Petaurids) of another individual (see Van Dyck, 1992b). It was also made in response to a human imitation of the 'na-when' call, and imitation was used to survey potential glider sites. One male was heard monotonously repeating this call. This individual was located 3m above ground, pressed head down against the trunk of a *Pandanus citraceus* and in its manner resembled a calling *P. breviceps*. This call was often shortened to a single nasal grunt 'hoy', and often appended by a low 'urga' or two. One sub-adult female once made the simple grunt 'arrgh' on detecting an adult female in a tree nearby. Animals unsure of their security (when exploring unfamiliar territory or when being handled) uttered a soft 'tock-tock'. Calls associated with consorting have been described under 'Reproduction'. Nestling young reunited with their mother after brief separation made a soft 'tzzz-tzzz' call on contact with the female.

DIET

The diet was assessed by directly observing gliders feeding or by analysis of faeces from captured individuals. The feeding observations described below are summarised in Table 6. See Van Dyck (1992b) for further discussion.

Nectar and pollen: Gliders were observed licking nectar (and presumably pollen) from the flowers of a range of trees and shrub species (Table 6). Five faecal pellets were collected during 4 months in 1991 and analysed for food items (Table 7). The pollen assemblage in February was entirely of Myrtaceae pollen, most of which was
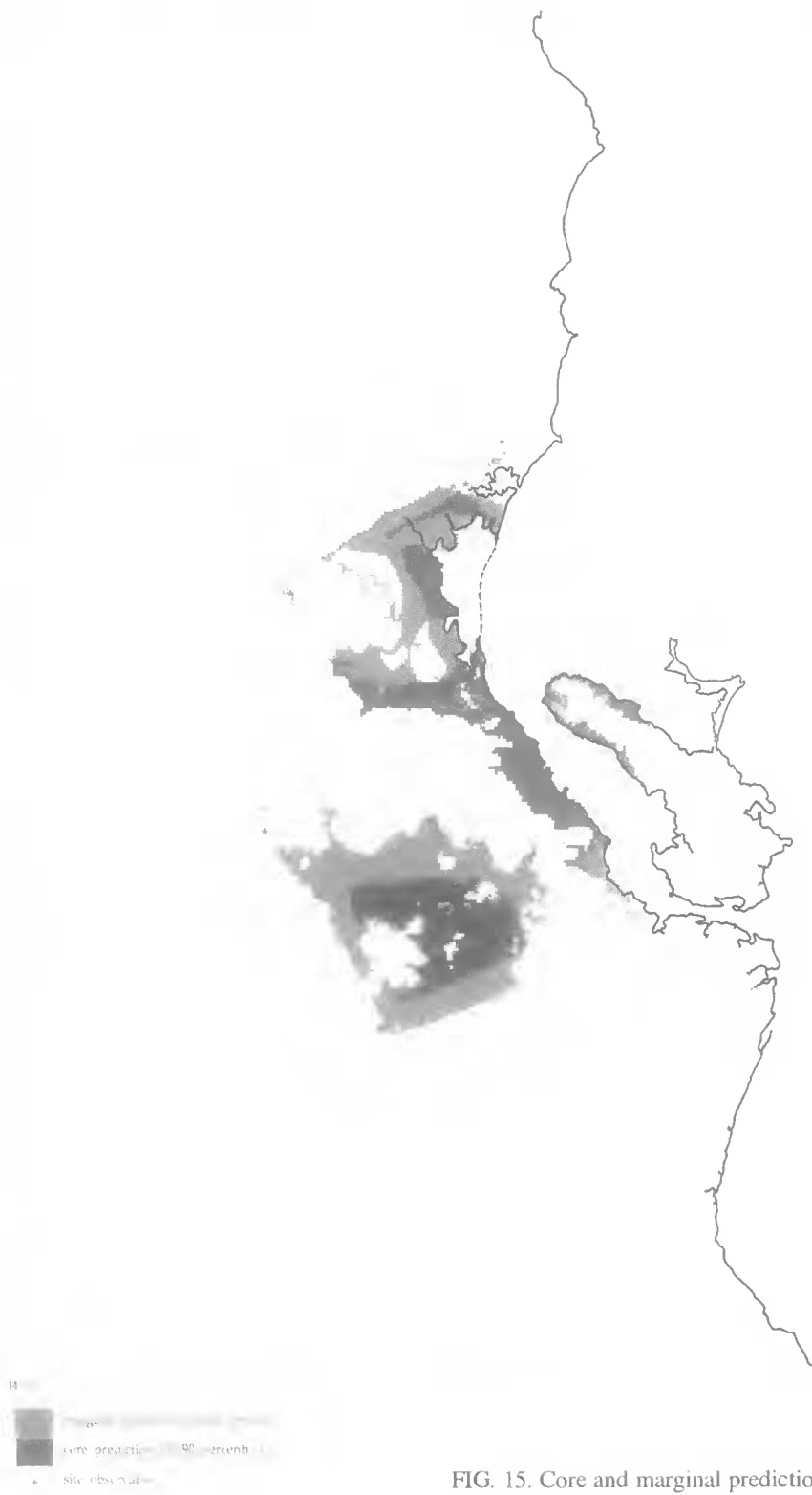
FIG. 15. Core and marginal predictions of *P. gracilis* distribution generated by the BIOCLIM prediction system. (Dotted line shows actual profile of coast).

```
af4026          (N=101)
Isopleth Areas    Max = 44.59 ha.
%  ha. (%max)      %  ha. (%max)
95 23.01 (51.61)  55 2.96 (6.64)
90 15.36 (34.44)  50 2.02 (4.54)
85 9.48 (21.26)   45 1.56 (3.49)
80 8.39 (18.81)   40 1.20 (2.70)
75 6.33 (14.19)   35 0.94 (2.10)
70 4.52 (10.13)   30 0.80 (1.80)
65 3.33 (7.47)    25 0.33 (0.75)
60 3.43 (7.69)    20 0.39 (0.87)
```
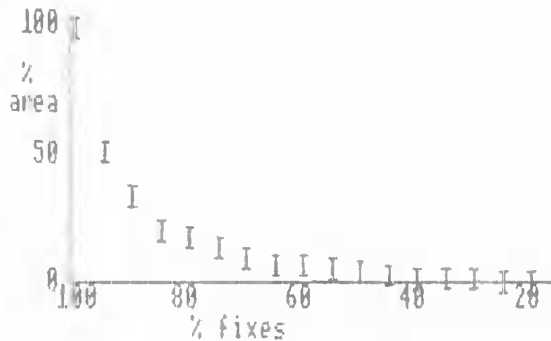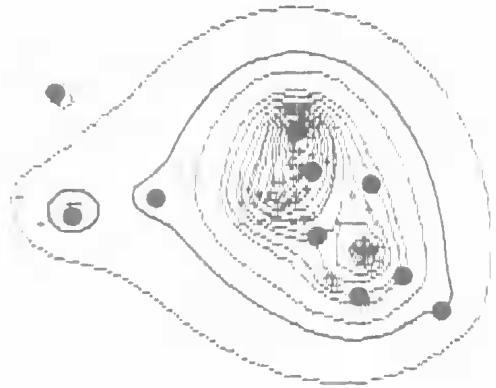

FIG. 16. Harmonic Mean Measure of home range and analysis for adult female T4026. Hard line is drawn over the 95% isopleth. Dots indicate dens used.

comparable to that of *Eucalyptus*. In May, plant material dominated the sample, but pollen was represented in low proportions; also represented were rhomboids of silica. The pollen assemblage contained approximately equal proportions of pollen of *Banksia* and *Xanthorrhoea*. *Banksia integrifolia aquilina*, the only species of banksia recorded at Barretts Lagoon occured very rarely at the study site.

One female glider was noted eating flower tassels of *Acacia crassicarpa* (each approx. 40mm long: 1 on 12 May 1991, 6-8 on 16 May 1991). Since this wattle produces no discernable nectar it was concluded that such ingestion constituted deliberate pollen feeding.

Xanthorrhoea johnsonii: Two radio-tagged female gliders (T4027, T4028) were observed over extended periods feeding on *X. johnsonii* during May 1991 when flowering was heavy (Table 6). Evidence of scape visitation ('scape' is used for the woody spear-like stalk of the *Xanthorrhoea* fruiting body) at other sites through footprinted scapes (see Fig. 23 and Van Dyck, 1992b) and scape damage, suggested that many other *P.gracilis* visited *X. johnsonii* (e.g. % green scapes footprinted at Nest Site (NS) 1 (see Table

4): 22%; NS2: 25%, NS3: 26%; NS4: 63%). The gliders' process of appraisal of the condition of scapes of *X. johnsonii* was conducted mostly at heights of less than 3m above the ground. Scapes were reached by leaps between thin saplings, small shrubs, dead sticks or other scapes. After landing on a scape, a glider would face downward, descend to within 30cm of the base, then turn and climb quickly up the spear. To reach more isolated scapes gliders crossed open ground in a series of rabbit-like hops through long grass. Fresh spikes ('spike' is used for the flowering head of the *Xanthorrhoea* fruiting body) were glided onto directly, but dried, seeded spikes were not, and although scapes of the previous season were climbed and investigated, the appraisal was abandoned usually within 30-60cm of the spike.

Young scapes with unformed spikes were chewed at the spike base and also at the scape base (Fig. 24) among the leaf insertions, and any amber-coloured mucilagenous exudate from earlier gougings licked off and eaten. *Xanthorrhoea* evaluation by *P. gracilis* occurred in frenetic bouts which ran for as long as 2.5hrs and covered linear distances of up to 800m. Suitable flowering heads were licked thoroughly for nectar (Fig. 25).

```
saf4028          (N=24)
Isopleth Areas   Max = 19.36 ha.
% ha. (%max)     % ha. (%max)
95 13.86 (71.60)   55 1.53 (7.91)
90  9.66 (49.91)   50 1.53 (7.91)
85  4.23 (21.83)   45 0.36 (1.85)
80  4.23 (21.83)   40 0.36 (1.85)
75  1.71 (8.85)    35 0.36 (1.85)
70  1.53 (7.91)    30 0.36 (1.85)
65  1.53 (7.91)    25 0.36 (1.85)
60  1.53 (7.91)    20 0.36 (1.85)
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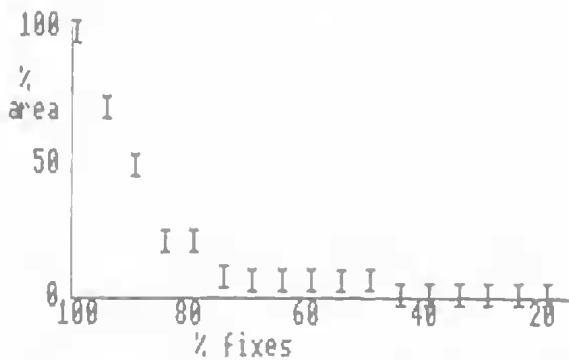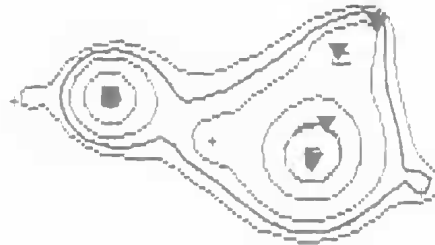
FIG. 17. Harmonic Mean Measure of home range and analysis for sub-adult female T4028. Hard line is drawn over the 95% isopleth. Dot indicates den used serially with adult female T4026. Triangles indicate other dens used.

One instance of eating unopened flowers was noted.

By August 1991 most *X. johnsonii* flowers had seeded (e.g. NS 1: 80%; NS 2: 50%; NS 3: 58%; NS 4: 62%) and experimental cuts which I made (5 Aug 1991) on immature scapes had produced no exudate up to 5 days after cutting. Although nectar-producing flowers occurred in the study area and pollen was abundant in one of two faecal samples taken (6, 9 Aug) (Table 7), none of the three gliders tracked during this period were recorded feeding on them. Hall (1956) demonstrated significant changes in spike component analysis from preflowering through to flowering. These included drops in protein (11.1% to 6.8%), carbohydrate (63.7% to 45.9%), fat (2.2% to 1.2%), phosphate (0.47% to 0.31%) and an increase in fibre (19.0% to 42.7%) as the spike matured.

Preliminary analysis results of dried gum exudate scraped from *X. johnsonii* scapes in Aug 1991 were as follows: moisture= 25.6%, protein (N × 6.25)=2.5%. Infra-red spectroscopy showed that the substance was a complex mixture consisting of polymerised and/or unpolymerised higher alcohols and acids. Some carbohydrates in free or bound form were probably also present, but no simple sugars were detected (N. Douglas, pers. comm.). No analysis was made of May *Xanthorrhoea* exudate.

Eucalyptus intermedia and E. pellita sap and/or kino: Gliders were often observed feeding at wound sites on *E. intermedia* (Table 6). Here they would pick crusts of dried exudate and lick the surface from which the crust had been taken. The wound was often accompanied by fresh red dribblings of kino which may have been ingested also.

One female glider (T4026) was observed licking and stripping fresh and old longitudinal incisions in the canopy branchlets of *E. intermedia* and *E. pellita* (Table 6). From the *E. intermedia* canopy the process was difficult to observe clearly, but large lumps of hard exudate falling from the glider's mouth were collected on the ground. The process was observed between 2050hrs 11 Aug 1991 and 0327hrs 12 Aug 1991 and involved alternating bouts of licking-biting and motionless rest with mouth away from the wound and eyes often closed (10min feeding, 1hr
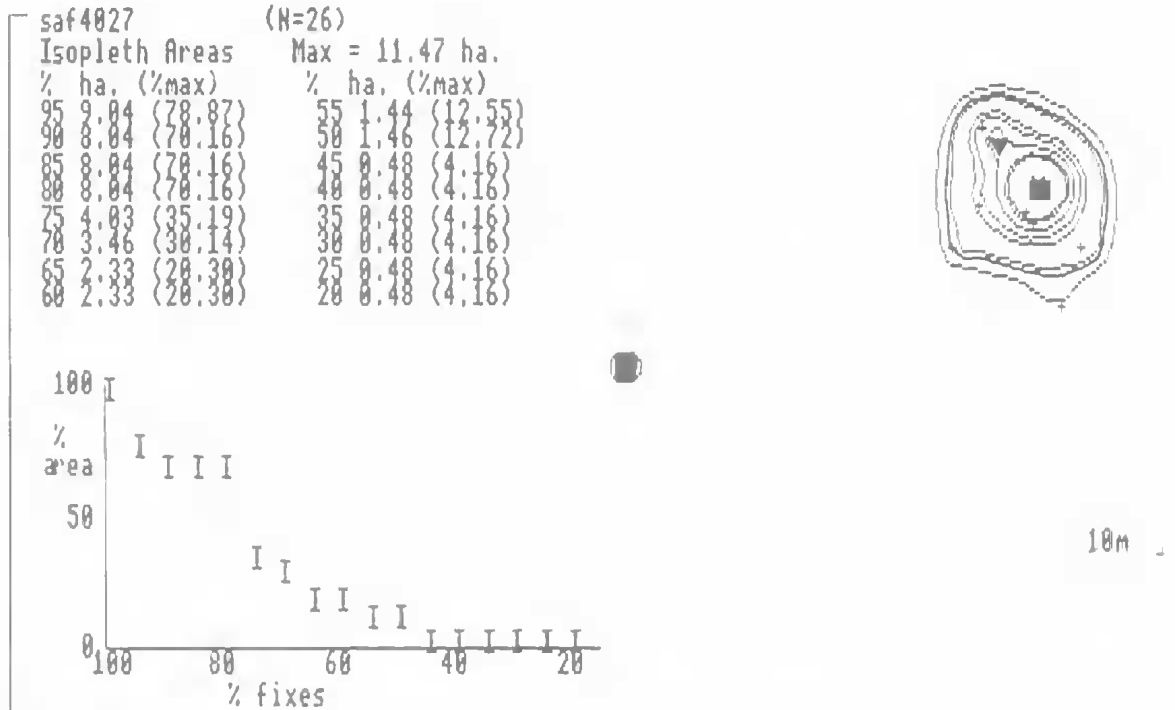
```
saf4027        (N=26)
Isopleth Areas    Max = 11.47 ha.
% ha. (%max)    % ha. (%max)
95 9.04 (78.87)   55 1.44 (12.55)
90 8.04 (70.16)   50 1.46 (12.72)
85 8.04 (70.16)   45 0.48 (4.16)
80 8.04 (70.16)   40 0.48 (4.16)
75 4.03 (35.19)   35 0.48 (4.16)
70 3.46 (30.14)   30 0.48 (4.16)
65 2.33 (20.38)   25 0.48 (4.16)
60 2.33 (20.38)   20 0.48 (4.16)
```

FIG. 18. Harmonic Mean Measure of home range and analysis for sub-adult female T4027. Hard line is drawn over the 95% isopleth. Triangle indicates den used conjointly with sub-adult female T4028. Squares indicate other dens used.

25min resting, 6min feeding, 28min resting, 7min feeding, 16min rest, 9min feeding, 5min rest. Total time feeding in *E. intermedia* 57min; total time resting 2hrs 27min. For *E. pellita* total time feeding 29min; resting 36min). Branchlets retrieved the following day from the feeding sites (approx. 17m high in the *E.intermedia* and approx. 8m in the *E. pellita*) showed many incisions of varying size and state of repair on thin branches that ranged from 4.7mm to 14mm in diameter (Fig. 26). For the *E. intermedia* sample (diameter 4.7- 12.9mm), incised cut lengths varied from 9.2-87.6mm (mean length= 46.4mm, N=16 from 9 branchlets all less than 40cm long) and cut width varied from 1.3-3.9mm (mean width: 3.2mm). For the *E. pellita* sample (diameter 10.1-14.00mm) incised cut lengths varied from 59.6-133.00mm (mean length= 91.5, N= 6 from 4 branchlets all less than 40cm long) and cut width varied from 2.0-7.6mm (mean width 3.3mm). Cuts from both species of eucalypt had healed and calloused leaving a raised 'lip'-like ridge around a ribbon of exposed sapwood. Cicadas had oviposited in the sapwood of most of these cuts (exposed sapwood of all long incisions (i.e. 9 >50mm) in the *E. intermedia* sample and of 4 in

the *E. pellita* sample). The fresh *E. intermedia* incision sites carried red kino stain on and under the calloused edges of the incision, but this was not as apparent in the *E. pellita* incisions.

A sample of bloodwood kino was taken from the branches showing fresh incisions. Preliminary analysis results were as follows: moisture 39.6%, protein (N $\times$ 6.25) 1.3%. Infra-red spectroscopy showed the substance was a complex mixture consisting of polymerised and/or unpolymerised higher alcohols, probably containing carbohydrate material either in bound or free form. It was not possible to characterise these components more precisely, or to determine the proportion of apparent carbohydrate in the exudate. However no simple sugars were present in free form (N. Douglas, pers. comm.).

Although not visible from the ground, wounds similar to those described above are very common in the small branches of the canopy in *E. intermedia*, *E. pellita* and *E. clarksoniana* throughout the range of *P. gracilis*. As yet there are no criteria for distinguishing cuts made by *P. gracilis* from those of *P. breviceps*, which occurs sympatrically with *P. gracilis* but is not tolerated socially by it.

FIG. 19. Overlap in home ranges of adult female T4026 (_____), sub-adult female T4027 (_ . _ . _) and sub-adult female T4028 (_ _ _ _). The MCP boundaries are represented by thin lines corresponding in pattern with the respective 95% isopleth indicated by the thick, curved lines. Crosses indicate the location of the 3 dens used by adult male T4030 over 3 consecutive nights (7-9 Sept 1991). Dots indicate the only 3 dens used by adult female T4031 during the period 9-15 Sept 1991. Arrows indicate the only natural corridor connecting land north and south of the central swale. Shaded areas indicate cleared land.
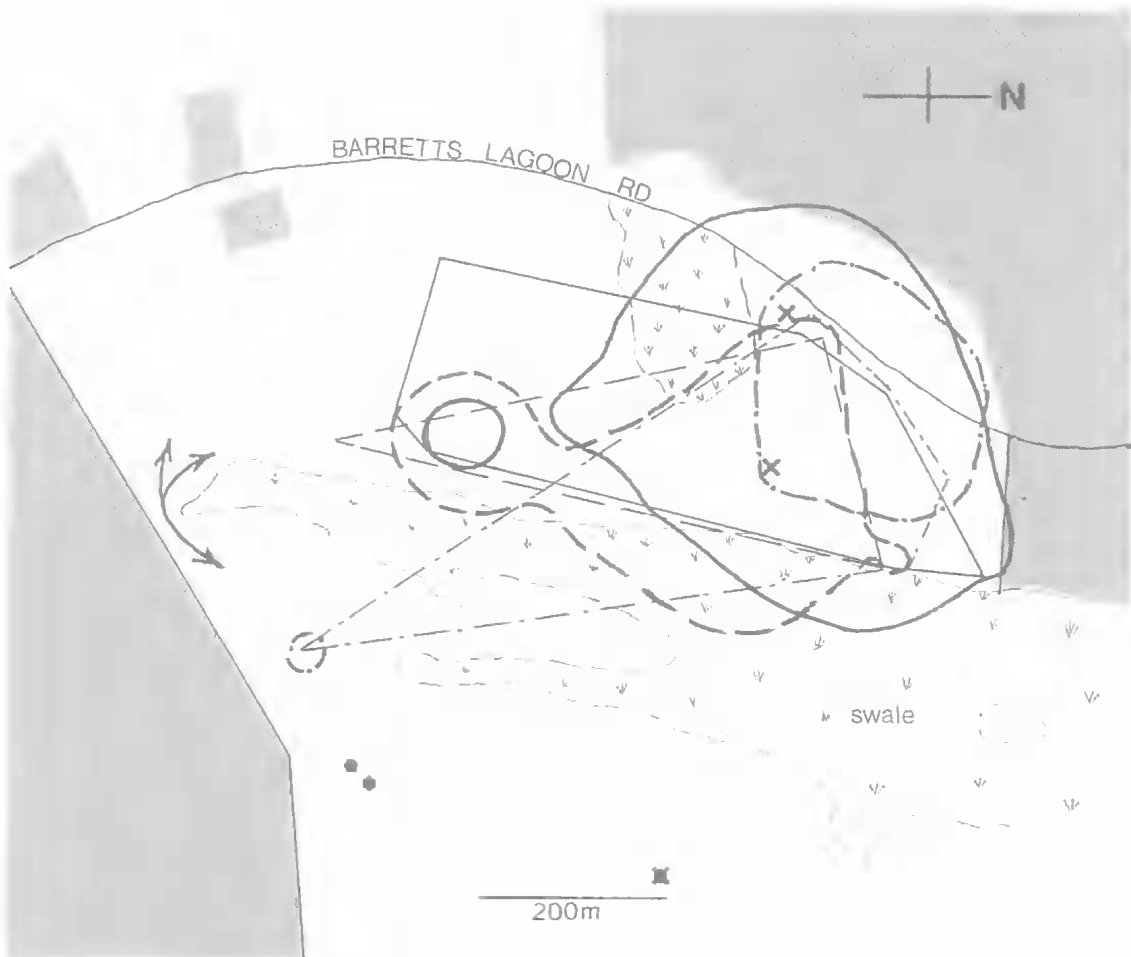
Acacia arils and gum: One female (T4026) was observed on 27 Nov 1991 from 1742 hrs to 0330 hrs (28 Nov 91) (Table 6). During that time the glider, which had fully furred young in the nest, fed almost exclusively on arils of *A. crassicarpa* (Fig. 27) which it collected from gaping pods. The only other food eaten during the night was a grasshopper/katydid caught by the glider while in the process of aril feeding. Gum exudates of *A. crassicarpa* were licked and new sites on a trunk were roughly gouged and torn open.

Lichens: A female (T4026) was observed 16 Aug 1991 from 0200hrs-0230hrs feeding on lichen growing on the bark of *Lophostemon suaveolens*. The glider chipped off flakes of bark, licked the lichens off then let the bark chip fall. A sample of lichen taken from the feeding site contained only clonal reproducing bodies (soredia) and was unidentifiable (R. Rogers, pers. comm.).

Psyllids and honey dew: A female (T4026) was observed on 13 Aug 1992 from 2000-2130hrs feeding on the psyllid *Eriococcus* sp. (Fig. 28) which had infested the underside of leaves in the canopy (at 10m) of an *E. pellita* (Table 6). The glider appeared to scrape and lick psyllids off the leaves' mid-vein. Results of preliminary analysis of scale insects are as follows: moisture= 55%, lipids= 13.2%, protein (N×6.25)= 20%. Of the

FIG. 20. Nestling young of female T4026 (T4032 and T4033) photographed 26 Nov 1991.

13.2% lipids in the sample, 6.3% could be re-garded as higher molecular weight glyceride waxes and the remaining 6.9% as fatty oils. The protein figure was obtained by applying the con-version factor normally used for converting nitro-gen content to protein, however nitrogen would be present not only in the protein but also in the chitin. The analysis was not able to differentiate between nitrogen derived from protein and that contained in chitin (N. Douglas, pers. comm.).

A male was observed on 2 Oct 1992 licking along the underside of *E. intermedia* leaves. It appeared to consume both the psyllid *Eucalyp-tolyma distincta* and its lerp (Fig. 29).

A female (T4026) was observed 13 Aug 1991 licking honey dew off the upper and lower sur-faces of leaves of *E.pellita*.

Other arthropods and arachnids: Large insects were usually manipulated and consumed while the glider hung upside-down by the hind legs against a tree trunk, leaving the forelimbs free to manipulate prey. In the case of a large grasshop-per, the gut was dismembered and extracted by biting and holding one end of the insect in the mouth, holding the other end in the forefeet, extending the forelimbs fully, tossing the head back and thereby stretching out the gut in a long string. A female (T4026) was once observed catching a flying moth by grabbing it with the forefeet alone.

On 13 Aug 1991, a female glider (T4026) was observed tearing into an occupied arboreal nest of

Green Tree Ants and for 5 minutes after, eating something taken from the nest. The act of breach-ing the nest was undertaken at some apparent discomfort to the glider which shook its legs and flicked ants off its body for the following 20 minutes.

The stomach of an adult male glider collected on 9 Dec 1989 while feeding in flowering *E. tessellaris* contained the remains of numerous scarabaeid beetles which, presumably, had also been feeding at the flowers.

Water: After rain, gliders were observed lick-ing water off petioles and leaves of *L. suaveolens* and *E. intermedia*. During rain, one glider was observed to move under the protective cover of a thick semi-horizontal branch. It remained still with head down until the rain passed. This animal dried its wet tail by thrashing it from side to side.

DISCUSSION

TAXONOMY

Alexander (1981) commented that, of the rec-ognised subspecies of *P. norfolcensis* and *P. bre-viceps*, *P. n. gracilis* and *P. b. longicaudatus* needed further detailed revision before they could be accepted as valid races. He noted that *P. n. gracilis* was based on one specimen from north of Cardwell, differing from the nominate subspe-cies in its markings, shorter ears, and a more slender tail; all features he demonstrated to be highly variable in specimens of *P. norfolcensis* from Queensland to Victoria. Had de Vis drawn attention to only those features, it could have been said that he described *P. gracilis* for all the wrong reasons. But de Vis also made a note that 'In size [*P. gracilis* was] intermediate between *B. austra-lis* and *B. sciureus* [*P. norfolcensis*]' (de Vis, 1883: 620), a significant statement that has not received the attention due to it in the literature. The set of measurements which accompany the de Vis description lie well outside those given by Thomas (1888) for specimens of *P. norfolcensis*. The lowland Tully-Ingham gliders I have attrib-uted to *P. gracilis* are, in size, consistent with the large dimensions outlined in the de Vis descrip-tion and, by the veracity they impart to the origi-nal measurements, reinforce the suspicion that neither Thomas nor subsequent authors who also dealt with *P. gracilis* as a synonym of *P. norfol-censis* had ever made a personal examination of either the specimen de Vis described in 1883, or of any other similar glider from nearby.

In body and tail length *P. gracilis* is similar to the large New Guinean glider *P. abidi* (Fig. 5).

FIG. 21. *Eucalyptus intermedia* nest tree (Nest Site 1 of Table 4) showing entrance hole (top arrow) 3m above nest (bottom arrow).

However, dental and biochemical systematic studies (Van Dyck, 1990; Colgan & Flannery, 1992) put *P. gracilis* closest to *P. norfolcensis*. The dental morphology of *P. abidi*, in particular the unreduced nature of P^2, the unreduced protocone of M^2, and the broad ectoloph of M^2 and M^3 suggest a more pleisomorphic species from which the Australian species *P. gracilis*, *P. norfolcensis* and *P. breviceps* could have been derived.

The large size of *P. gracilis* is worth noting in the context of its close affinities with *P. norfolcensis*. Alexander (1981) concluded that Victorian populations of *P. norfolcensis* were significantly larger than those of southeast Queensland, and that the size increase from north to south was gradual and continuous, thereby representing a latitudinal clinal variation in body size which could be attributed to Bergmann's rule. All adult specimens of *P. gracilis* examined (from latitudes 18°02'-18°27') were larger in skull length (maxskull length: mean= 51.14, N=

7, SD= 0.95) than Victorian *P. norfolcensis* (mean= 47.52, N= 5, SD= 0.64) from latitudes 36°23'-38°26', and significantly larger (P<0.001) in body length than Victorian *P.norfolcensis* (for *P. gracilis* mean= 247.45, N= 11, SD= 15.86; for *P. norfolcensis* mean= 212.40, N= 5, SD= 16.69). This reversal in the clinal trend in *P. gracilis* is offset by normal trends attributable to Bergmann's rule seen in other possums and gliders such as *P. breviceps* (Smith, 1973), *P. australis* (Russell, 1984), *Petauroides volans* and *Trichosurus vulpecula* (Yom-Tov & Nix, 1986).

FOOD SELECTION

It is as difficult to account for the selective pressures resulting in large body size in *P. gracilis*, as it is to interpret the 'impetus for body size development' (Smith & Lee, 1984) in the entire Petauridae given the minor dietary differences between the species. Among exudivores *P. gracilis* is more of a dietary opportunist, feeding on nectar, pollen, arthropods, arachnids, wattle exudates, honeydew and eucalypt saps when these food items become seasonally available. Although similar diets have been thoroughly documented for other petaurids such as *P. breviceps* (Fleay, 1947; Smith, 1980, 1982; Suckling, 1980; Suckling & McFarlane, 1983) and *P. australis* (Smith & Russell, 1982; Henry & Craig, 1984; Craig, 1985; Goldingay, 1986, 1987; Kavanagh, 1987a, 1987b) the occurrence of other significant dietary items such as *Acacia* arils, *Xanthorrhoea* exudates, *E.intermedia* sap and/or kino, lichens and green tree ants (or the contents of their nests) has not been reported for the group.

Australian *Acacia* species have been divided into three dispersal groups (O'Dowd & Gill, 1986): 1, arillate *Acacia* that are bird dispersed (17% of 92 species sampled); 2, arillate *Acacia* that are ant dispersed (74%); and 3, the remaining non-arillate *Acacia* species (9%) that do not correlate with dispersal by ants or birds. O'Dowd & Gill showed that in bird-syndrome species diaspores (dispersal units) were as follows: predominately bicoloured, displayed in dehisced pods retained in the canopy, high in aril mass and lipid content and significantly longer and more contorted than in ant dispersed *Acacia*. Diaspores of ant-syndrome species were presented inconspicuously on the ground and investment was low.

In the broad sense, bird and ant dispersed seeds are thought to escape from interspecific competition, fire, parental competition and seed predators, and/or benefit from transportation to

a bird-syndrome *Acacia* whose arils, though not brightly coloured, are long (convoluted around 14mm) and prominently displayed (Fig. 27) in the canopy over many weeks. Female gliders in late lactation (December) with nestling young in dens surrounded by seeding *A. crassicarpa* might be expected to significantly reduce energy costs by foraging on arils close to the nursery den. As the gliders did not eat the *Acacia* seeds, but discarded them below the tree, it is doubtful that the tree derives anything advantageous from the relationship.

The August 1991 observation of a glider breaching an occupied arboreal nest of Green Tree Ants and for 5 minutes thereafter eating something taken from the nest, deserves comment here. Larvae were initially considered the objects of the glider's attention. However, nests breached by M. Hopkins (pers. comm.) in an

FIG. 22. *Lophostemon suaveolens* nest tree (Nest Site 3 of Table 4) showing relative size of entrance hole.

microsites with superior nutrients (Holldobler & Wilson, 1990). O'Dowd & Gill (1986) considered two of these most relevant to the *Acacia* group: escape from the detrimental effects associated with the parent plant, and an increased chance of being directed to specific microhabitats by the dispersal agent. They note that in some *Acacia* species, lipids might account for 70% of the aril dry mass, a value comparable to the highest lipid contents observed in seeds and fruits. They argue that lipids provide a greater energy reward per unit mass of aril, since lipids yield roughly twice the energy upon catabolism as carbohydrates, and they conclude that since most of the known dispersal agents of *Acacia* are generalist feeders and incorporate insects into their diet, the higher proportion of saturated fatty acids may 'mimic' the saturated fatty acid composition typically found in animal prey.

Petaurus gracilis stands to gain much from the summer aril harvest provided by *A. crassicarpa*,

FIG. 23. New scapes of *Xanthorrhoea johnsonii* carry a 'bloom' of waxy spicules. Gliders visiting scapes leave long-lasting footprints in the wax. Surveys of *P. gracilis* habitat are facilitated by an inspection of *Xanthorrhoea* inflorescenses.

FIG. 24. *Xanthorrhoea johnsonii* scape showing tapping gouges attributed to *P. gracilis.*

unrelated study, were found to contain abundant harvested *Acacia* arils. Three *Acacia* species occur commonly in *P. gracilis* habitat: *A. crassicarpa*, *A. flavescens* and *A. mangium*. However the three species flower concurrently through May making it unlikely that mature arils would be available for harvest and storage as early as mid-August. Given the longevity of arils it is possible that the items extracted from the nest were arils harvested by the ants the previous summer.

The grasstree *Xanthorrhoea johnsonii* has a wide geographic and environmental range on the east coast, tablelands and western slopes from Cape York Peninsula south to Singleton, New South Wales (Bedford et al., 1986). Unlike most other glider sites within the surveyed area, *X. johnsonii* was common at Barretts Lagoon with densities exceeding 1000 plants per $1000m^2$. There, soils were waterlogged for extended periods during the wet season, and flowering in both 1991 (a non-fire year) and 1992 (severe fire in

early January) occurred from May to August. During this time both *P. gracilis* and *P. breviceps* were observed feeding (separately) on spike nectar, but only *P.gracilis* was observed tapping young scapes for exudate (Van Dyck, 1992b). As scapes and spikes matured it became difficult to distinguish between scape damage due to gliders and that caused by insects. Large crickets were noted grazing broad (5mm) shallow channels in immature upper scapes which later oozed exudate and calloused to leave scars similar to those left by gliders. As scapes further matured, a glider's bite at the base of a scape could have been interpreted as either a gum tap or an attempt to get at worm-like beetle larvae that sometimes excavated burrow networks in the lower part of the scape.

Pollen analysis showed *Xanthorrhoea* pollen intake between May and August and rhomboidal crystals of silica in the May 10 sample. The presence of the silica crystals demonstrates that

FIG. 25. *Xanthorrhoea johnsonii* spike being licked by sub-adult female *P. gracilis* T4027.
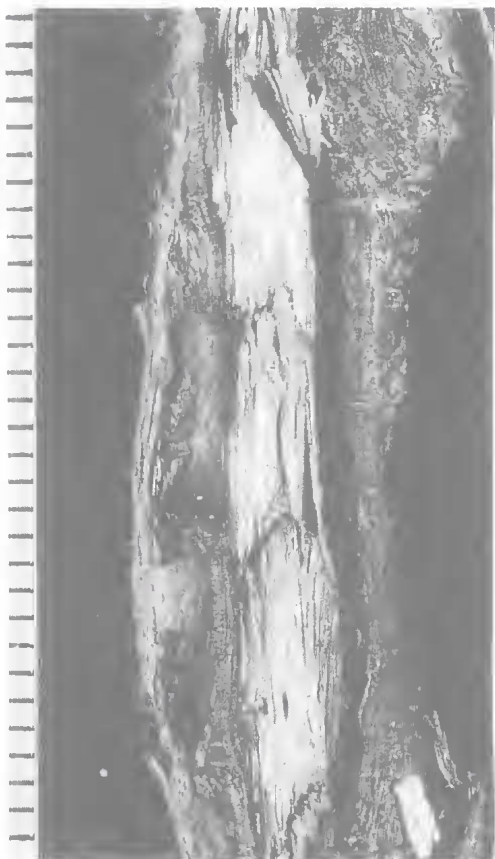
FIG. 26. Branch of *Eucalyptus intermedia* stripped for sap and/or kino by *P. gracilis*. Note cicada ovipositions.

the glider may have foraged scape tissue of *Xanthorrhoea*, as rhomboidal silica surrounds the secondary bundles of this taxon (Staff & Waterhouse, 1982). In May, a high proportion of scapes were tender and, presumably most productive when tapped. The results also suggest a high percentage (up to 70%) of *Xanthorrhoea* pollen is available for digestion through release of the contents via the aperture. *Xanthorrhoea* pollen may provide a convenient and rich source of protein by virtue of the high ratio of pollen aperture to surface area making the contents more readily available than pollen from other sources e.g. *Eucalyptus* (M. Dettmann, pers. comm.). Pollen has a high protein content (6-34%, Smith, 1982). Given the carbohydrate and protein rewards offered by *X. johnsonii* over a long period, the intake of scape exudate is noteworthy in respect of its possible digestibility-reducing or toxic secondary plant compounds. Investigations of the complex mixture of aromatic compounds

found in *Xanthorrhoea* have concentrated on resins present in the trunk (Birch & Hextall, 1955; Duewell 1955, 1965, 1968; Duewell & Haig 1968) but not in the scape. Phenols and flavinoids are known components of young scapes (D. Bedford, pers. comm.) and their injestion by cattle has been attributed to poisonings during autumn and early winter in north Queensland (the sometimes fatal condition known as 'wamps' or 'crampy disease'). The toxic principle involved in such poisonings has not been investigated (Everist, 1974). Hall (1956, 1965) noted that young *Xanthorrhoea* spikes (probably *X. fulva*, D. Bedford, pers. comm.) appeared to be more toxic than old ones, and there was evidence to suggest that the scape was more poisonous than the spike.

Australian folivorous marsupials have been shown to exhibit a number of physiological and morphological adaptations to cope with xenobiotic compounds such as tannins and other polyphenols in their diets (Hume et al., 1984; Foley, 1987; Foley & Hume, 1987; Foley et al., 1987). The development of the hindgut, in particular the caecum, into a fermenting chamber, is
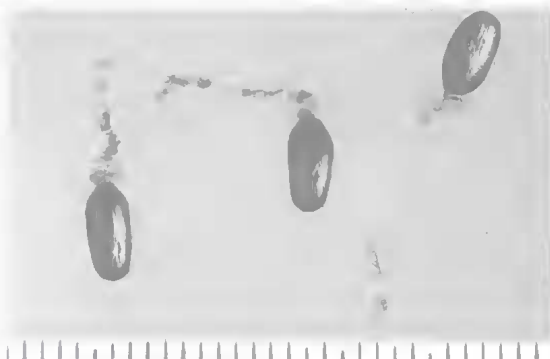
FIG. 27. Prominently displayed seeds and arils of the 'bird-syndrome' *Acacia crassicarpa*. This *Acacia* is an important understorey component of *P. gracilis* habitat.

FIG. 28. *Eriococcus* sp. on *Eucalyptus pellita* foliage. Both scale and psyllid are eaten by *P. gracilis*.

one of these adaptations and its role in the bacterial fermentation of carbohydrate polymers (some plant gums) eaten by petaurids is discussed by Smith (1982a, 1982b). In external proportions, the alimentary tract of *P. gracilis* (Fig. 30) resembles that of *P. breviceps*. In one specimen of *P. gracilis* (JM7400), the small intestine (44cm) tapered gradually from 1.3cm diameter below the duodenum to 2.9cm diameter at the point of juncture with the hindgut and caecum. The caecum was 7.8cm long and broadest at 1.5cm. The colon was long (25cm). The length of the caecum in *P. gracilis* was roughly twice that (or 11.3% of total gut length) of the caecum in the striped possum *Dactylopsila trivirgata* (6.9% of total gut length, see Smith, 1982b). The colon in *P. gracilis* occupied approximately 36% of total gut length and compared to 17.2% in *D. trivirgata*. The striped possum has a similar body weight to, and occurs sympatrically with, *P. gracilis* through most of the latter's range. If this difference in the capacity of the hindgut reflects a physiological advantage in *P gracilis* to deal more successfully with the toxic polyphenols and complex carbohydrates of *Xanthorrhoea* gums and exudates, it may provide further ecological segregation between the two species.

This segregation may further be reinforced by the ability of *P. gracilis* to deal with lichens whose secondary chemicals (toxic polyphenols) may be a defense response to predation or an aggressive allelopathic response (Lawrey, 1986;

Rogers, 1990) and Pink Bloodwood (*E. intermedia*) sap and/or kino (although precisely which one of these or what proportions the glider takes from branchlet slashings and small trunk wounds is not known). Old, red-stained, calloused slashings were often found to be fed by kino ducts, and did not display crusted kino on the wound, suggesting that either this type of wound may not crust over naturally, or gliders may have cleared away or eaten the crystalline form and then fed on kino liquor as it leaked into the wound. Kino, the 'blood' from which the group of 'bloodwood' eucalypts are renowned and named, is astringent to taste and contains large quantities of toxic polyphenols (Smith, 1982). The results of chemical analysis of Pink Bloodwood kino from Barretts Lagoon suggested broad superficial similarities to *Xanthorrhoea* exudate. Gliders of any species have not previously been reported to feed on kino.

Phloem sap feeding is well documented for *P.*

FIG. 29. *Eucalyptolyma distincta* on *Eucalyptus intermedia* foliage. Both lerp and psyllid are eaten by *P. gracilis*.

FIG. 30. Dissected gut of *P. gracilis* (JM7400).

breviceps and *P. australis* (see previous references). Smith (1982) noted that when gliders fed on sap they were generally seen to chew the sides of the wound and Craig (1985) described bark stripping in *P. australis* where bark and adhering conducting tissues of both *E. cypellocarpa* and *E. obliqua* were stripped to a depth of 1-2mm and torn free in long slivers, which were immediately discarded and the damaged surface licked intensively. It is possible that similar gouging behaviour observed in *P. gracilis* in the canopies of both *E. intermedia* and *E. pellita* was directed at phloem sap and not at kino. In that no actively

worked sap-site trunks such as those characteristic of *P. australis* were detected over the course of the survey, it may be that for *E. intermedia* at least, thin canopy branches provide the most convenient access to phloem sap where trunk gouging might be too quickly counteracted by a kino injury response. Given the critical importance of the northern bloodwood complex (*E. intermedia, E. clarksoniana, E. dolichocarpa*) to the distribution of *P. gracilis* (see below), the shortcomings associated with knowledge of this glider's relationship with these species need to be addressed. Given its relatively large size, *P. gracilis* may be dependent on this group for incising and thereby the geographic range of the glider is, in part, determined by the presence of these trees.

DISTRIBUTION AND HABITAT

Sites supporting *P. gracilis* are characterised by very high (seasonal) precipitation and a woodland vegetation blend that is shaped and maintained by fire. The glider's narrow range coincides with the wettest zone in Australia (Tully's mean yearly total rainfall is 4188mm). Coastal areas at the southern limit of the *P. gracilis* range may appear suitable in habitat (e.g. Clemant State Forest 34, near Rollingstone) yet fail to support petaurids other than *P. breviceps*. Large, mature woodland trees of the coastal ridges and plains (e.g. *E. intermedia, E. pellita, L. suaveolens*) are shallow-rooted, and although trees in such low-lying areas are subject to protracted periods of seasonal inundation, their sandy soils also drain quickly and thoroughly during the extended winter-spring dry season. It is most likely that the ultimate climatic parameter determining the distribution of *P. gracilis* is a dry season moisture threshold (probably close to 100mm dry quarter precipitation) below which its moisture demands cannot be easily satisfied.

Ironically, the high rainfall requirement which partly determines the glider's presence in an area also potentially undermines its long-term survival prospects. Many dryland communities suitable to *P. gracilis* are actively evolving from sclerophyll to vine forest because of changing fire regimes (P. Stanton pers. comm.). Traditional burning practices no longer operate in the area and the threat of economic loss through damage to sugarcane and pine plantations acts as a discouragement to burning-off in adjoining woodland areas. This is linked to a public perception that fires are a 'bad' thing and rainforests are 'best'. Rapidly evolving rainforest communities
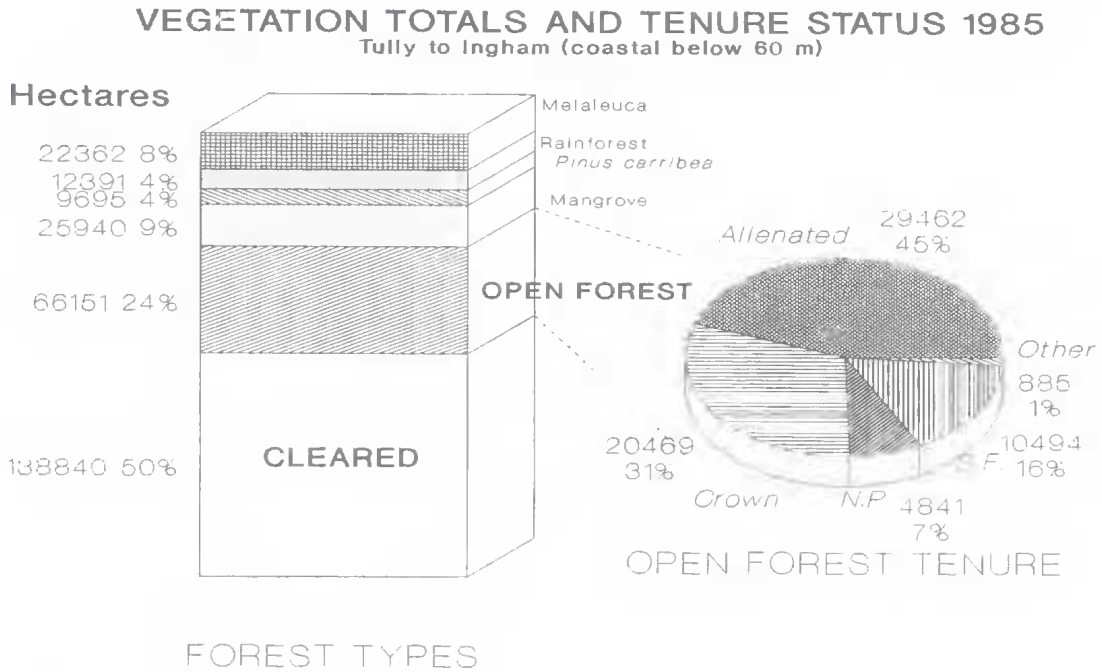
VEGETATION TOTALS AND TENURE STATUS 1985
Tully to Ingham (coastal below 60 m)

FIG. 31.The status of vegetation types (in general) and open forest (in particular) throughout the range of *P. gracilis.* For coverage see Fig. 1 (Smiths Gap south to Bambaru). Figures supplied by Queensland Forest Service.

were noted in woodlands at the Hull River site, Edmund Kennedy National Park, Murray Upper, Hinchinbrook Is. and parts of Barretts Lagoon.

Petaurus gracilis is dependent on mature stands of mixed-species remnant woodland. The presence of at least one of the 'bloodwood' group (*E. intermedia, E. clarksoniana, E. dolichocarpa*) and an accompanying species of bird-syndrome *Acacia* (usually *A. crassicarpa*, less often *A. flavescens* or *A. mangium*) is suggested as a minimal basis for suitable habitat. In a few cases, the place of a bloodwood might be taken by *E. pellita*. This species flowers heavily in February and March, coinciding with bloodwood flowering. Hypanthums of *E. pellita* blossoms range from 6-10mm, and gliders have been observed to spend entire nights feeding in individual trees (see Goldingay, 1987, 1989 for similar behaviour in *P. australis* at single sap-sites). The presence of *E. pellita* was considered to indicate areas of high quality glider habitat. Where mature *E. pellita* combined with *Xanthorrhoea johnsonii*, the resultant habitat blend could often be regarded as optimal (e.g. areas of Barretts Lagoon). Habitat considered sub-optimal was characterised by a trend

toward species-poor assemblages and dominance by a single eucalypt species e.g. *E. platyphylla* (Wharps Holding), *E. clohesiana* (Hinchinbrook Is.), *E. intermedia* (Graham Range National Park). A curious human bias toward leaving mature *E. tereticornis* in cultivated paddocks and narrow belts along roadsides (e.g. Kennedy Valley, Ashton and Lannercost Creeks) has meant that gliders can often occupy heavily degraded and fragmented habitat where vestiges of suitable riparian (gully) habitat provide summer requirements. *Eucalyptus tereticornis*, a mid-winter flowering species is known as a major source of winter pollen and a useful source of nectar (Penfold & Willis, 1961; Chippendale, 1988). Also the presence of many large mature specimens of *Deplanchea tetraphylla* distributed sparsely but evenly throughout the glider's range is considered important in that they provided an abundant source of nectar (and perhaps pollen) at a time (August, September) when little else is in flower.

SOCIAL ORGANISATION AND HOME RANGE

The small sample size upon which these comments are based should not be ignored. Barretts

FIG. 32. Lowland woodland clearing for *Pinus carribea* plantations has accounted for a loss of at least 9,695ha of *P. gracilis* habitat. In late 1992 Queensland Forest Service suspended clearing of native forests near Cardwell following the recording of *P. gracilis* in foothill remnants at Porters Creek (shown here overlooking Hinchinbrook Is.).

Lagoon, where a total of five gliders were radiotagged, included patches of habitat considered optimal for *P. gracilis*. The woodland community was structurally complex with abundant species of *Eucalyptus* (4), *Melaleuca* (4), *Acacia* (4) and with a dense understorey of *Xanthorrhoea*. The availability of diverse sources of carbohydrate and protein throughout the year (see Table 6), combined with an abundance of nest sites, could be expected to be reflected in a polygynous mating system (Emlen & Oring, 1977; Lee & Cockburn, 1985; Henry, 1984; Goldingay, 1992) as polygyny in the Petauridae is thought to evolve when resources are abundant enough for male gliders to defend a territory which can support more than one female consort. However, *P. gracilis* appears unconventional in its pattern of social organisation. The two adult females in this study had home ranges that appeared to be relatively exclusive of one another (Fig. 19). Two dispersing sub-adult females were largely solitary although their home ranges overlapped consistently with one another and with one of the adult

females (presumed to be their mother). The adult male denned either alone or with either solitary adult female and regularly spent time with at least one of them for part of the night. This system is a departure from the nature of polygynous mating systems generally attributed to either *P. breviceps* (polygynous: Smith, 1980; Suckling, 1980) or *P. australis* (monogamous: Craig, 1985; Goldingay & Kavanagh, 1990; polygynous or monogamous: Russell, 1984; Goldingay, 1992). The apparent system in *P. gracilis* more closely approximates that seen in *Petauroides volans* (Henry, 1984; Kehl & Boorsboom, 1984), although the home range is much larger in *P. gracilis* (23ha for an adult female compared to 1.25-2.5ha in a *P. volans* female), and the investment in female and/or resource defense by male *P. gracilis* could be anticipated to greatly exceed that by male *P. volans*.

It is tempting to draw similarities between the social behaviour of *P. gracilis* and that of the tropical African exudivorous prosimian *Galago senegalensis moholi* as reviewed by Bearder

TABLE 6. Food items recorded for *P. gracilis* by direct observation.

Food item	Source	Month recorded	Locality (from Table 1)
	Blossoms of:		
Nectar and pollen	*E. pellita*	Feb, Mar	7, 14, 15, 19
	E. clarksoniana	Mar	6, 14
	M. elleryana	Mar	9
	X. johnsonii	May	19
	A. crassicarpa	May	19
	E. tereticornis	Jun	5, 19
	D. tetraphylla	Aug	19
	M. dealbata	Oct	19, 1
	E. tessellaris	Nov	19
Incision exudates	*A. crassicarpa*	May	19
	X. johnsonii	May	19
	E. intermedia	Sep	19
	E. pellita	Sep	19
Acacia arils	*A. crassicarpa*	Dec	19
Lichen	*L. suaveolens*	Aug	19
Spiders/Insects	large (?huntsman) spider	May	19
	cockroach/beetle	May	19
	green ants or nest contents	Sep	19
	moth	Sep	19
	grasshopper/ katydid	Dec	19
Psyllids and lerp			
Erriococcus sp.	*E. pellita*	Aug	19
	E. intermedia	Aug	19
Eucalyptolyma distincta	E. intermedia	Oct	20
Honey dew	*E. pellita*	Sep	19

(1987). In *G. senegalensis moholi*, female territories are large enough to support feeding throughout the year and in homogeneous habitat, home ranges of females are approximately equal in size. Females signal territory ownership to conspecifics by scent marking and vocalisation; only adult females are repulsed. At first an adult daughter may share her mother's territory, but later there is less overlap although related females may share critical resources (up to 4 adult *P. gracilis* were once recorded feeding simultaneously in a single flowering *E. tessellaris* at Barretts Lagoon). Territories of male *G. senegalensis moholi* (i.e. 'A-males', which are older, heavier

and territorial and have preferential contacts with females) overlap those of one or more females. A-male territories are signalled by scent and vocalisation and other adult males are repulsed. There is no relationship between male territory size and dietary requirements. A special bond of familiarity links a territorial male to his females. This bond is serviced by regular visits that involve direct contact with the females. The direct contact may be prolonged (several hours). Additionally, calling and indirect contact using scent marking may be employed. Male stability and territoriality depends on the presence of females. Male-male and female-female territories (between matriachies) have zones of overlap where territorial signals are exchanged.

Bearder (1987) notes that such a strategy in *G. senegalensis moholi* ensures the even spacing of single females or matriarchies throughout areas of suitable habitat and ensures that the nature of male territoriality ensures mating access to females without wasting energy on subordinates. Smith & Lee (1984) comment that theoretically, female possums might be expected to obtain more nutrients for survival and reproduction when solitary (and defending solitary territories) except when specific advantages of clumping outweigh the disadvantages of sharing resources. Given the combination of its moderately large size, and the benign tropical climate associated with its habitat, *P. gracilis* could be expected to have a low relative cost of thermoregulation and as a result it may avoid group huddling.

The threat from Rufous Owls (*Ninox rufa*) and Lesser Sooty Owls (*Tyto multipunctata*) which occur commonly throughout the range of *P. gracilis* may also make lone foraging a response to crypsis for defense (Henry, 1984, for this behaviour in *P. volans*). Of 5 regurgitated pellets retrieved from a Rufous Owl's nest site at Lannercost, 1 pellet contained maxillary fragments of an adult specimen of *P. gracilis*.

The Barretts Lagoon situation may reflect an artificial situation in that the adult female home ranges were separated by an extensive treeless swale with one narrow natural corridor connection at the southern end (Fig. 19). The western side of one of those home ranges was bordered by a road. Investments in female resource defense by the male may have thereby been greatly reduced, and elsewhere, in areas of more contiguous habitat, *P. gracilis* way prove to exhibit a mating system compatible with that described for other petaurids.

If the mating system at Barretts Lagoon was

typical, the quasi-polygynous system may offer abundant resources of food and time to reproductive males, yet just sufficient resources for reproductive females to feed themselves, and tolerate two, large, weaned young (and perhaps a second litter) dispersing slowly from the female's home range. The use by females of multiple dens scattered throughout the home range may represent a cost effective method of territory defense. Home range size and mating strategy have been shown to vary in *P. australis* with the productivity of the site (see Goldingay, 1992 for review). It is likely that in marginal to poor habitats (e.g. Wharps Holding), the socieccology of *P. gracilis* will vary from that of Barretts Lagoon.

CONSERVATION STATUS

Most records of *P. gracilis* (Table 1) have come from altitudes below the 60m contour (mean altitude= 17m; SD= 19.8; SE= 0.35; N= 57). The total area encompassing site records to date of *P. gracilis* is shown in Fig. 31. Of this total area which amounts to 438,454ha, approx. 63% (275,379ha) occurs below the 60m contour. Of this lowland vegetation approx. 50.4% (138,840 ha) has been totally cleared of forest through primary production (mainly establishment of sugar-cane, cattle, bananas, pineapples, fruit trees, aquaculture), logging, and the cultivation of *Pinus carribea* in plantations (9.695 ha) since 1967. The balance of open forest which totals approx. 66,151ha and represents a surviving approx. 20% of the original component of lowland open forest (P. Stanton, I. Robb, pers. comms), is highly fragmented, the subject of ad hoc fire regimes and mostly unprotected. Approximately 76% of this remnant is potentially available for future development (45% alienated (i.e. freehold/leased), 31% Crown). *Petaurus gracilis* is poorly represented in the 7% (4841ha) open forest protected by National Park tenure (see preceding), and the remaining significant slice of 16% (State Forest, 10,494ha) is highly fragmented. In late 1992, Queensland Forest Service (QFS) suspended clearing of native forest near Cardwell following the recording of *P. gracilis* in State Forest at Porters Creek. Seven specific areas of the coastal lowlands had been selected by QFS for clearing prior to the establishment of exotic pine plantations (total area 3710 ha). Each area was investigated by the QFS Fauna Conservation and Ecology Section in October 1992 to determine the presence of *P. gracilis* and to allow an evaluation of the conservation significance of each proposed area as *P. gracilis* habitat. Gliders were detected in 4 of the 7 sites investigated (total area 3050ha) and in locating gliders at Wharps Holding, QFS ecologists extended the known southerly distribution of the species (J. Kehl, pers. comm.).

Core areas predicted by the BIOCLIM system have been mostly cleared from the north and south and replaced along the Ingham-Tully coast by plantation pine (Fig. 32). Records from predicted marginal areas indicate the present day distribution is concentrated near foothills and relictual riparian corridors. The extensive area east and south of Barretts Lagoon represents a significant remnant core area.

The endangered status of *P. gracilis* (Van Dyck, 1991) in tropical Queensland should not be regarded in isolation, but seen as symptomatic of a pattern of decline of abundance and extinction repeated across Australia. The threats faced by this glider are not unique to it but shared by the entire tropical coastal lowland woodland ecosystem of which it is one component. In 1982, Tracey commented that his Vegetation Types 18 (Swampy Coastal Plains) and 19 (Coastal Floodplains and Piedmont Swamps) had been either cleared and drained for sugar-cane, or where they had once been common along the Tully River and Murray River were now practically extinct. Braby (1992) reviewed the status and biology of eleven species of butterfly dependent on the Cardwell Basin lowland woodlands and concluded that their habitat ranked among the most threatened habitats in north Queensland. Recher & Lim (1990) presented data suggesting that the decline of vertebrates first observed in southern Australia has extended to the northern parts of the continent and that fauna of the wetter coastal regions may also be affected. They predicted that if such observations are correct, the outcome will be the rapid extinction of species throughout Australia in the next few decades. They recommend that in the conservation of terrestrial fauna, the emphasis needs to shift from species preservation to the management of ecosystems.

'The scale of change is not of individuals or populations, but of functional units of interacting organisms. Once destroyed it is no more likely that an ecosystem can be restored to its original state than an extinct species can be resurrected from its bones recovered from a museum drawer' (Recher & Lim, 1990: 295).

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TABLE 7. Macerals and pollen types identified in faecal samples of *P. gracilis* from Barretts Lagoon, 1991. Frequency: H = high, M = moderate, L = low. Abundance: A = abundant, C = common, R = rare.

Slide contents	Feb	10 May	6 Aug	9 Aug	26 Nov
CONTROL SLIDE (maceral type)					
Pollen	M	L	H	L	M
Other plant mat.	M	H	M	H	H
Insect fragments	M	L	M	M	L
Silica crystals		L			
% pollen with contents	40	50	30	20	20
POLLEN SLIDE (pollen type/ abundance)					
Myrtaceae	A	R		A	A
Banksia		C			
Xanthorrhoea		C	A	C	
Grevillea/Hakea				R	
Acacia				R	

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